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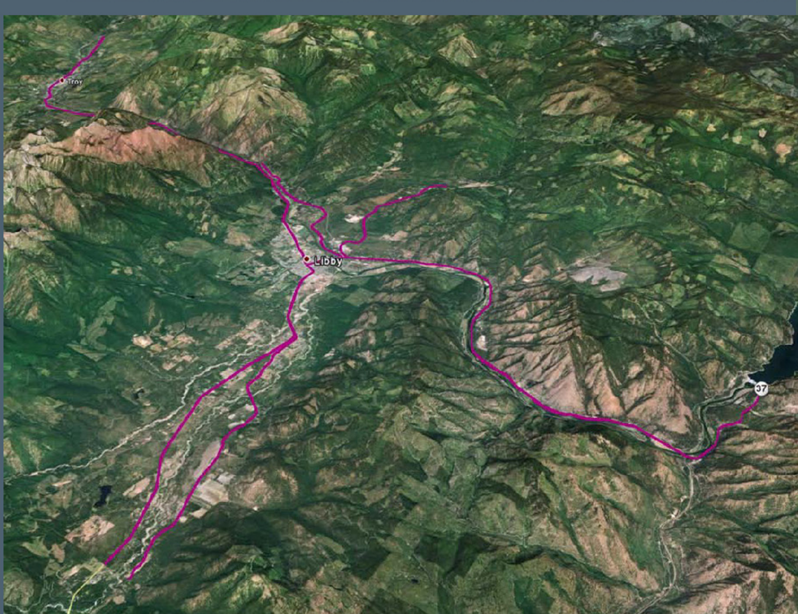
Libby, Montana

FINAL Remedial Investigation Report

Operable Unit 8
Libby Asbestos National Priorities List Site

June 2013



EPA United States Environmental Protection Agency

"...to protect human health and to safeguard the natural environment..."

FINAL
Remedial Investigation Report

Operable Unit 8
Local and State Highways in Libby and Troy
Libby Asbestos National Priorities List Site
Libby, Montana

June 2013

Prepared for
US Environmental Protection Agency

by

HDR Engineering, Inc.

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LIST OF ACRONYMS

ABS	Activity-Based Sampling
AM	Amosite
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	All Terrain Vehicle
bgs	below ground surface
CSF	Close Support Facility
COC	Chain of Custody
DQA	Data Quality Assessment
DQOs	Data Quality Objectives
EDD's	Electronic Data Deliverables
EPA	U.S. Environmental Protection Agency
ERT	Emergency Response Team
ESAT	Environmental Services Assistance Team
FSDS	Field sample data sheet
Ft	Feet
Ft/day	Feet per day
ISO	International Organization for Standardization
LA	Libby Amphibole
MCE	Mixed Cellulose Ester
MDOT	Montana Department of Transportation
ND	Non-Detect
NPL	National Priority List
OUs	Operable Units
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscopy Equivalent
PLM	Polarized light microscopy
PLM-VE	Polarized Light Microscopy – Visual Estimation
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
ROW	Right-Of-Way
s/cc	structures per cubic centimeter
SAP	Sampling and Analysis Plan
SERAS	Scientific, Engineering, Response and Analytical Services Program
SH2	State Highway 2
SH37	State Highway 37
SOPs	Standard Operating Procedures
TEM	Transmission Electron Microscopy
µm	micrometer

EXECUTIVE SUMMARY

Overview

This Remedial Investigation (RI) Report describes the nature and extent of Libby amphibole (LA) asbestos at Operable Unit 8 (OU8) of the Libby Asbestos National Priority List (NPL) Site located in Libby, Lincoln County, Montana (the Site). An evaluation of potential exposures to and risks from LA will be included in the site-wide risk assessments for the Libby Asbestos Superfund Site.

Operable Unit 8 is also referred to as state and local highways and includes segments of roadway right-of-way (ROW) in and within 30 miles of Libby (Figure ES-1).

Gold miners discovered vermiculite in Libby in 1881; in the 1920s the Zonolite Company formed and began mining the vermiculite. In 1963, W.R. Grace bought the Zonolite mining operations which closed in 1990. While in operation, the Libby mine may have produced 80 percent of the world's supply of vermiculite. Vermiculite has been used in building insulation and as a soil conditioner.

Vermiculite often contained asbestos and therefore, vermiculite mining, processing, and shipping acted as a carrier to spread asbestos throughout Libby. Raw vermiculite ore was estimated to contain up to 26% LA.

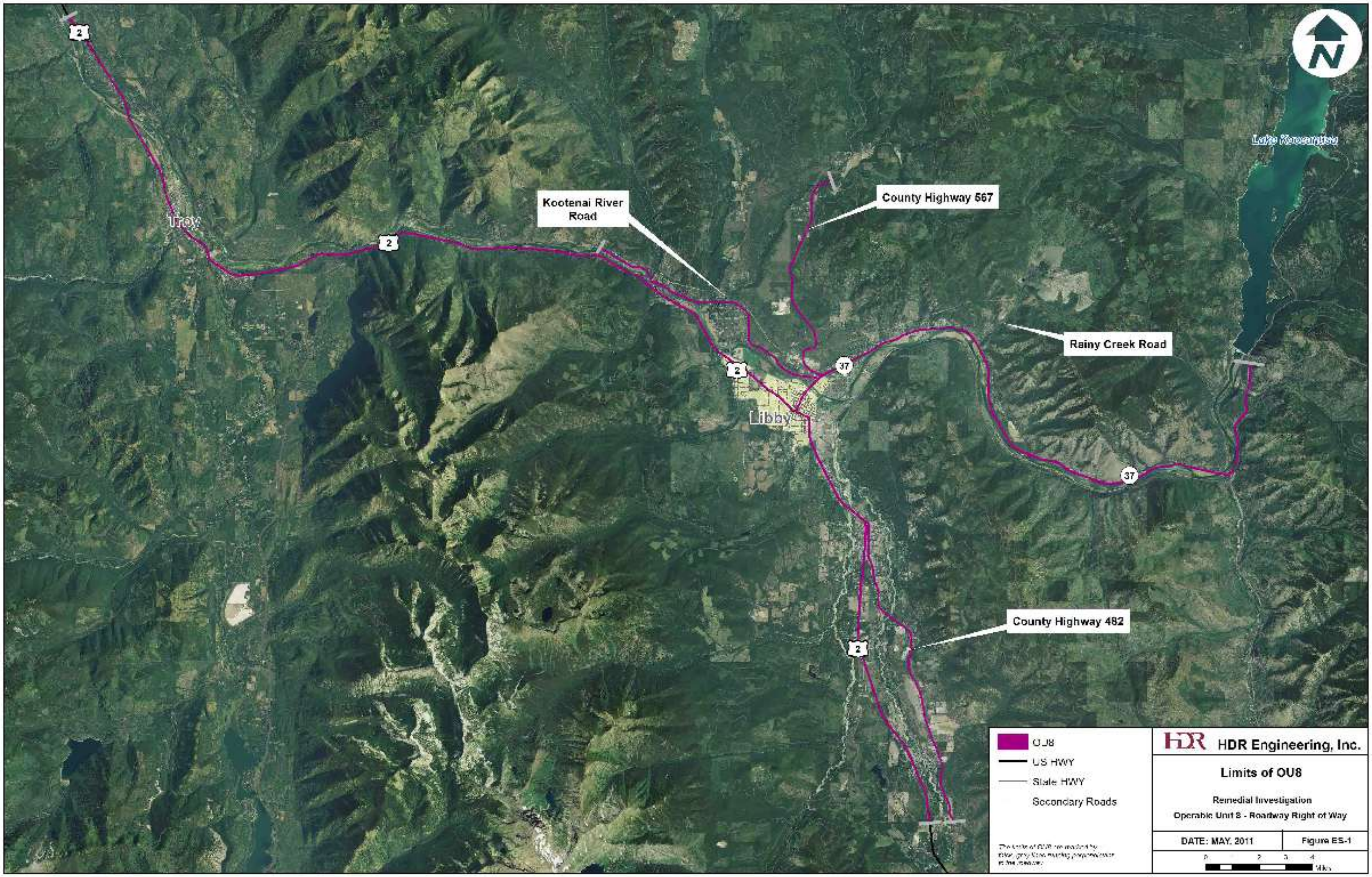
Asbestos found at the Libby Site contains a variety of different amphibole types. Amphibole is the name of an important group of generally dark-colored minerals, forming prism or needlelike crystals. Because there are presently insufficient toxicological data to distinguish between the different forms of amphibole asbestos, the Environmental Protection Agency (EPA) evaluates all of the mine-related amphibole asbestos types together (referred to as LA). Asbestos exposure in humans may cause both cancer and non-cancer effects. Among them are:

Non-Cancer Effects:
- Asbestosis
- Pleural Abnormalities

Cancer Effects:
- Lung cancer
- Mesothelioma

People who visit or work at OU8 may be exposed to LA by incidental ingestion of contaminated soil or dust and by inhalation of air that contains LA fibers. Of these two pathways, inhalation exposure is considered to be of greater concern as it is most often associated with disease of the respiratory system.

Asbestos fibers can be released into the air due to disturbance of asbestos containing environmental media such as soil. The amount of LA fibers released into the air at the site will vary depending upon the level of LA in the source material and the intensity and duration of the disturbance activity. Because of this, predicting LA levels in air associated with disturbance activities based only on measured LA levels in source material is extremely difficult. Therefore, the most direct way to determine potential exposures from inhalation is to measure, through sampling and analysis, the concentration of LA in air during a specific activity that disturbs a source material. For convenience, this is referred to as activity-based sampling (ABS).


Troy
Kootenai River Road
County Highway 567
Rainy Creek Road
Libby
Lake Koocanusa
County Highway 482
2
37
OU8
US HWY
State HWY
Secondary Roads
HDR Engineering, Inc.
Limits of OU8
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MAY, 2011
Figure ES-1
Miles

Site Investigations

Once OU8 was established in 2009, EPA conducted extensive sampling of soil and air during 2010 and 2011 as part of the remedial investigation including the following media-specific sampling:

- Soils
  - Surface – composite samples collected from as much as 6-inches bgs.
- Air
  - Personal air samples – collected using a sampling pump and filter located in the breathing zone of an individual (or mounted on equipment) while performing various outdoor activities.
  - Stationary air samples – collected using a stationary sampling pump and filter placed in a location that acts as a surrogate for a personal air sample.

Soil samples were collected and analyzed for LA in order to determine the distribution of LA (and visible vermiculite) along roadway ROWs. This information was used to, among other things; determine whether ABS sampling was performed over a range of LA levels and visible vermiculite conditions. Visible vermiculite is often used as an indicator for the presence of LA. In most cases, one composite soil sample was created from ten aliquots collected for every 1,000 ft of ROW. A total of 485 field (non-QC) composite soil samples were collected from July 7 to September 10, 2010. Of these, 397 contained no detectable LA and the remaining 88 samples contained trace levels of LA.

Visible vermiculite was not observed in composite soil samples with the exception of those collected along the far eastern end of State Highway 37 (Figure ES-1). In this area, more than ten samples contained visible vermiculite. However, polarized light microscopy results for these samples were non-detect to trace for LA, which is typical of the rest of the OU. It is not clear why vermiculite was noted by visual inspection but LA was not detected by laboratory analyses.

ABS air samples were collected in association with the following activities:

Recreational Activities

- Riding all terrain vehicles (ATV) with a lead and following ATV.

Montana Department of Transportation (MDOT) Maintenance Activities

- Rotomilling of asphalt pavement (removing the top layer by grinding)
- Grass cutting and brush hogging (cutting to remove shrubs and saplings) in ROWs.

All ATV, brush hogging and grass cutting ABS sampling during the 2010-2011 OU8 Field Program was conducted along Hwy 37 between Libby and Rainy Creek Road (Figure ES-1). This portion of roadway was selected for ABS based on the presence of LA and visible vermiculite in surface soils as determined during investigations in 2003 and 2005. Samplers were mounted on the front and back of the grass cutting and brush hogging equipment as well as on the “following” ATV.

Rotomilling ABS sampling was performed along Hwy 37 in downtown Libby as part of regularly scheduled maintenance work conducted by the MDOT. The general area of interest (California Ave.) was selected because one of several asphalt core samples collected in California Ave. in March 2010 contained a trace (0.1%) of LA.

Rotomilling ABS consisted of samplers mounted on the moving rotomill as well as on a small front-end loader. In addition, stationary samplers were positioned on the sidewalk adjacent to the street where rotomilling operations were conducted. These samplers comprised the “inner perimeter” sampling stations.

In addition to the ABS sampling, several stationary air samplers were placed at various locations within downtown Libby but remote from the rotomilling operations. Samples collected from these locations are representative of ambient conditions and are referred to as “outer perimeter” samples.

Sample results are summarized below:

- Of the 34 ABS air samples associated with ATV riding, brush hogging and grass cutting, LA was detected in 8 samples. Of those, 7 were associated with brush hogging and one was found in association with ATV riding.
- Of the 10 ABS air samples collected from rotomilling equipment, no LA was detected.
- Of the 51 air samples collected from the inner perimeter, only one contained detectable LA.
- Of the 25 ambient air samples collected around downtown Libby, none contained detectable LA.

In addition to the data discussed above, EPA conducted certain limited investigations of LA in surface soil between 2003 and 2005. This work focused on the segment of Montana State Highway 37 between Libby and Rainy Creek Road (See Figure ES-1). These data revealed the presence of LA in some soil samples.

<u>Risk Assessment</u>

An evaluation of potential exposures to and risks from LA will be included in the site-wide risk assessments for the Libby Asbestos Superfund Site. Site-wide risk assessments are stand-alone documents which support the feasibility study and record of decision.

1.0 INTRODUCTION

1.1 OVERVIEW AND REPORT ORGANIZATION

This Remedial Investigation (RI) Report describes the nature and extent of Libby amphibole (LA) asbestos and associated human health risks at Operable Unit 8 (OU8) of the Libby Asbestos National Priority List (NPL) Site (the Site). LA occurrence throughout the Site resulted from long time mining, processing, and shipping activities and the use and handling of materials which contained LA.

U.S. Environmental Protection Agency (EPA) has had a presence in Libby since 1999 and has completed a number of sampling activities and clean up efforts. The EPA determined there was an imminent and substantial endangerment to public health from asbestos contamination in various types of source materials in and around Libby.

In light of evidence of human asbestos exposure and associated increase in health risks, it was recommended that EPA take appropriate steps to reduce or eliminate exposure pathways to these materials to protect area residents and workers. In 2002, the Libby Asbestos Superfund Site was included on the NPL, which due to its large size, has been divided into eight Operable Units (OUs):

- OU1 – Former Export Plant
- OU2 – Former Screening Plant
- OU3 – Mine Site
- OU4 – Residential and commercial properties in and around Libby
- OU5 – Former Stimson Lumber Mill
- OU6 – Rail Line
- OU7 – Residential and commercial properties in and around Troy
- OU8 – US and Montana State highways and secondary highways in the vicinity of Libby and Troy, Montana.

Figure 1-1 presents a map showing the entire NPL area and boundaries of all OUs. This RI addresses OU8, which includes various State and local highways in the vicinity of Libby and Troy, Montana.

As determined by previous investigations conducted at the Site, LA is present in multiple environmental media. During 2003 and 2005 soil samples were collected along portions of State Highway 37 (SH37) and were found to contain LA and visible vermiculite (CDM, 2005). During 2006 and 2007, soil and air samples were collected during routine maintenance activities performed by the MDOT. LA was detected in some of those samples. In March 2010, five asphalt core samples were taken from California Street and US Highway 2 (in downtown Libby) and analyzed for asbestos. In one of the core samples, a trace (0.1%) of LA was detected indicating LA may be embedded in the roads in and around Libby (Lockheed Martin, 2010a). Based on this evidence, EPA established OU8 and began planning for the RI described in this report.

The RI Report is organized into the following major sections:

Section 1 – Introduction – This section describes the purpose of the RI and summarizes prior work and NPL Site history.

Section 2 – Site Characteristics – This section provides a brief description of Site setting, climate, geology, hydrogeology, and surface water hydrology.

Section 3 – Sampling and Analyses – This section discusses sample types and collection methods and analytical techniques.

Section 4 – Data Recording, Data Quality Assessment, and Data Selection – This section discusses the Libby database, quality control measures and how data were selected to produce the final OU8 data set used to describe the nature and extent of contamination.

Section 5 – Nature and Extent of LA – This section provides a description of the current type and extent of LA in surface soils and outdoor air.

Section 6 – Contaminant Fate and Transport – This section provides a qualitative discussion of LA contaminant migration routes and persistence in the environment.

Section 7 – Human Health Risk Assessment – This section discusses the human health and ecological risk assessment

Section 8 – Conclusions – This section presents general conclusions.

Section 9 – References – This section provides full references for all citations in the body of the report.

1.2 NPL SITE LOCATION & TOPOGRAPHY

The City of Libby, Montana is located in the northwest corner of the state, 35 miles east of Idaho and 65 miles south of the Canadian border (Figure 1-1). It is at an elevation of approximately 2,580 feet (ft) above mean sea level (msl). The source of LA, Vermiculite Mountain, is located approximately 7 miles northwest of Libby. The city has a total area of 1.3 square miles and lies in a valley carved by the Kootenai River and bounded by the Cabinet Mountains to the south.

Operable Unit No. OU8 consists of the ROW of the following State and local highway segments (See Figure 1-2):

- Montana State Highway 37 (SH37)
- Montana State Highway 2 (SH2)
- Kootenai River Road
- County Highway 482 (Farm to Market Road)
- County Highway 567 (Pipe Creek Road)

1.3 NPL SITE HISTORY

Libby is located near a large open-pit vermiculite mine located on Vermiculite Mountain. Vermiculite is a mica-like mineral that can be processed for use as an insulating material or soil amendment and was mined in Libby between 1919 and 1990. It is estimated that the Libby mine was the source of over 70 percent of all vermiculite sold in the U.S. from 1919 to 1990. Over its lifetime, it employed more than 1,900 people. W. R. Grace bought the mine and processing facility in 1963 and operated it until 1990 (EPA, 2010).

Vermiculite from this mine contains varying levels of amphibole asbestos, consisting primarily of winchite and richterite, with lower levels of tremolite, magnesioriebeckite, and possibly actinolite. Because existing toxicological data are not sufficient to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, the EPA simply refers to the mixture as LA asbestos. Historic mining, milling, and processing operations, as well as bulk transfer of mining-related materials, tailings, and waste to locations throughout the Libby Valley resulted in releases of vermiculite and LA to the environment. This has caused a range of adverse health effects in exposed people, including individuals who did not work at the mine or processing facilities.

The EPA has been working in Libby since 1999 when an Emergency Response Team was sent to investigate local concerns and news articles about asbestos-contaminated vermiculite. Since that time, the EPA has been working closely with the community to clean up contamination and reduce risks to human health.

Based on health risks associated with asbestos, which include asbestosis, lung cancer and mesothelioma, EPA placed the Libby Asbestos Site on the NPL in October 2002.

Libby, Montana, which is the Lincoln County seat, has a population of less than 3,000, and 12,000 people live within a ten-mile radius. While Libby's economy is still largely supported by natural resources such as logging and mining, there are also many tourist and recreational opportunities in the area.

1.4 REGULATORY HISTORY

The following is a brief chronological summary of major regulatory actions taken at the Site.

- 1999 – Local concern alerts EPA to investigate asbestos in and around Libby, Montana
- 2002 – Libby Asbestos Site proposed for the NPL
- 2002 – Libby Asbestos Site formally added to the NPL
- 2009 – Operable Unit No. 8 added to the Site.

EPA has not entered into any enforcement agreements or issued any orders for investigation, removal, or remedial work at any part OU8. However, EPA has addressed some parts of OU8 along with the remedial actions for other OUs. EPA addressed the portion of Highway 37 adjacent to OUs 1 and 2 as part of their respective removal and remedial actions. These actions were not pursuant to any enforcement agreement or order. They were funded with special account money under the settlement EPA entered into with W. R. Grace, in 2008. That agreement provided for a cash settlement of past and future response costs owed by W.R. Grace for the entire Libby NPL Site except OU3, the mine site.

1.5 PREVIOUS INVESTIGATIONS & REPORTS

Prior to the designation of OU8 as a Site Operable Unit, several investigations generated data from areas that lie within current OU8 boundaries. In addition, OU8-specific investigations were conducted in 2010 and 2011. Planning documents for these investigations and associated reports are listed below:

<u>Sampling and Analysis Plans</u>

- *Sampling and Analysis Plan/Quality Assurance Project Plan for Activity-Based Outdoor/Air Exposures, Operable Unit 8, Libby Asbestos Site, Libby, Montana, 2010 Sampling Events. Prepared by TechLaw. Revision Date July 15, 2010.*

<u>Reports on Investigation Results (pre-OU8 designation) Containing Data Relevant to OU8</u>

- *Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. Final Summary Report for the J. Neils Park and Montana State Highway 37 Investigations, Revision 1. Prepared By CDM. December 2005.*

- *Report of Findings, Potentially Asbestos-Containing Soil in MTD Rights-of-Way, Traction Sand and Road Aggregate Sources, Collected Road Sweepings, and Sampled Worker Air Space During Routine Maintenance Activities, Libby, Montana. Prepared By Tetra Tech, Inc., February 21, 2007.*

- *Report of Findings, Sampled Worker Air Space during Routine Maintenance Activities, Libby, Montana. Prepared By Tetra Tech, Inc., July 19, 2007.*

<u>Sampling Investigation Results Reports Specific to OU8 (post-OU8 designation)</u>

- *Verification Summary Report for Operable Unit 8, Libby Asbestos Superfund Site (Based on Scribe database provided on 1/27/11), Prepared by SRC. February 1, 2011.*

- *Trip Report (on ABS activities), Libby Asbestos Site, Libby, Montana. Prepared by Lockheed Martin Scientific, Engineering, Response and Analytical Services. November 1, 2010.*

- *Trip Report (on Rotomilling ABS Activities and Ambient Air Sampling), Libby Asbestos Site, Libby, Montana. Prepared by Lockheed Martin Scientific, Engineering, Response and Analytical Services. June 24, 2011.*

2.0 SITE CHARACTERISTICS

Operable Unit 8 encompasses a large geographic area but is constrained to roadway rights-of-way (ROW). Therefore, an OU-specific detailed discussion of many site characteristics, such as geology, is impractical for linear features such as a roadway. In addition, the investigation of LA in OU8 is restricted to surface soil and air. Therefore, subsurface conditions are not relevant to the RI. As a result, the following discussion of Site characteristics is based on conditions in and around Libby where such information has been developed as a part of work in other OUs.

2.1 CLIMATE

Annual average precipitation in Libby is 24.7 inches, with an annual average of 105 inches of snowfall (WRCC, 2010). Precipitation and humidity in Libby are greatest during the winter months due to the presence of temperature-regulating Pacific air masses. In December and January, average temperatures range between 25-30 ºF. Occasionally, dry continental air masses occupy the Libby area for short periods of time during the winter, creating cold and less-humid conditions (CDM, 2009).

Fog is common in Libby during winter months and in early morning throughout the year. Summer months are drier than winter and are warm with occasional rainfall. The average July temperature ranges between 56-70 ºF, with an average high of 80 ºF (CDM, 2009).

Prevailing winds are from the west north-west and average approximately 6-7 miles per hour. Wind direction and velocities fluctuate depending on temperature variances caused by vertical relief in the area. Inversions often trap stagnant air in the Libby valley (CDM, 2009).

2.2 GEOLOGY

Regional geology in the Libby valley is comprised of lacustrine deposits underlain by Precambrian rocks. Surrounding mountains are formed by Precambrian rocks. Cliffs along the lower portion of the valley are formed by glacial lake bed deposits. The Kootenai River and Libby Creek cut through lacustrine and alluvial deposits and form a discontinuous sequence of gravel, sand, silt, and clay (EPA, 2010b).

Alluvial deposits extend from the surface to 190 ft bgs and are comprised of sand, gravel, silt, clay and cobbles. Glacial till, which consists primarily of silt and clay with varying amounts of sand and gravel, underlies alluvial deposits. Deposits of glacial till are believed to be quite deep, occurring at depths exceeding 500 ft bgs (EPA, 2010b).

Soils in the Libby area typically are loamy soil composed of sand and silt with minor amounts of clay. Soil was formed by erosion of Precambrian rocks, downstream transport of clays by rivers and creeks, and organic matter from historically forested areas (CDM, 2009).

Site soils are a combination of historical soil modified in areas by human activities. These activities may include addition of vermiculite as a soil amendment, soil reworking for building construction, road and railroad operation, vermiculite processing and transport, and general site work.

2.3 HYDROLOGY AND HYDROGEOLOGY

Within OU8, portions of SH 2 and SH 37 follow the Kootenai River and runoff from these roadways discharges to the river. In addition, the portion of SH 2 south of Libby parallels Libby Creek. The Kootenai River originates in British Columbia, Canada, and flows through Montana and Idaho before returning to Canada and flowing into the Columbia River. Flows in the Kootenai River and Libby Creek are tied to runoff from the mountains surrounding Libby. Runoff peaks in spring when high-elevation snow begins to melt. Stream flow decreases in summer due to low precipitation and snowmelt flow moderation by high elevation lakes (CDM, 2009).

Based on investigations at the Libby Groundwater Site (a separate NPL Site within the Libby Asbestos NPL Site), the hydrogeology in the southeast portion of Libby consists of saturated alluvial deposits extending from the surface to approximately 190 ft bgs. These deposits have been sorted into three classifications: upper aquifer, intermediate zone, and lower aquifer. The upper aquifer contains high hydraulic conductivity material including silty gravel and sand with occasional interbedded clayey, silty deposits. It is unconfined and extends from the water table (5 to 30 ft bgs) to approximately 70 ft bgs. Hydraulic conductivity ranges from 100 to 1,000 feet per day (ft/day). The inferred groundwater flow direction is north-northwest towards the Kooteni River (EPA, 2010b).

The intermediate zone is comprised of low permeability deposits similar to the upper aquifer, but with a higher percentage of fine-grained material. Acting as a confining layer, the intermediate zone is 40 to 60 ft thick, extending from approximately 60-70 ft bgs to 110 ft bgs. The hydraulic conductivity of this layer is much lower than the upper aquifer at approximately 1 ft/day.

The lower aquifer extends from approximately 100 ft bgs to 190 ft bgs, and contains more low-permeability silt and clay layers than the upper aquifer. It is confined and under pressure, so water in wells screened in this aquifer rises to 14-26 ft bgs. Hydraulic conductivity of the lower aquifer ranges from 50 to 200 ft/day. The inferred groundwater flow direction is north-northwest towards the Kooteni River (EPA, 2010b).

3.0 SAMPLING AND ANALYSIS

Most analytical and other data relevant to OU8 were collected during 2010 and 2011, after OU8 was established. However, some data relevant to OU8 were collected prior to 2010 as part of the investigation of other OUs or Site-wide investigations. Table 3-1 summarizes all sampling events that generated data relevant to OU8.

The following sections describe sample types, sample collection and analytical methods. All sample media and associated analytical results are discussed in this section. However, certain data are excluded from the discussion of nature and extent of LA occurrence (Section 5) including:

- Data that were deemed irrelevant to the assessment of risk to human health. These include certain indoor dust and outdoor ambient air samples and street sweepings.

- Occupational Safety and Health Administration compliance monitoring data for EPA contractors working on the remedial investigation.

This was done to simplify and focus the description of nature and extent of LA occurrence to those measurements most relevant to the estimation of human health risks.

3.1 SAMPLE TYPES AND COLLECTION PROCEDURES

As shown in Table 3-1, the following media-specific sampling was conducted:

- Soils
    - ➢ Surface – composite samples collected from as much as 6-inches bgs.
- Air
    - ➢ Personal air samples – collected using a sampling pump and filter located in the breathing zone of an individual (or mounted on equipment) while performing various outdoor activities.
    - ➢ Stationary air samples – collected using stationary sampling pump and filter placed in a location that acts as a surrogate for a personal air sample.

Samples were collected, documented, and handled in accord with standard operating procedures (SOPs) as specified in the respective Sampling and Analysis Plans (SAPs) prepared for the various investigations summarized on Table 3-1. Additional details on the 2010 and 2011 RI Field Programs including the study design and data quality objectives (DQOs) is provided in the Quality Assurance Project Plan (QAPP; Lockheed Martin, 2010a).

Data documenting sample type, location, collection method, and collection date were recorded both in a field log book maintained by the field sampling team and on a field sample data sheet (FSDS) designed to facilitate data entry into the Libby site database, as described in Section 4.1.

All samples collected in the field were maintained under chain of custody (COC) during sample handling, preparation, shipment, and analysis.

3.1.1 Soil Samples

Composite soil samples were collected along both sides of the ROW from the following roadways in OU8 (See Figure 3-1):

- Montana SH37
- Montana SH2
- Kootenai River Road
- County Highway 482 (Farm to Market Road)
- County Highway 567 (Pipe Creek Road)

The soil samples were collected and analyzed for LA in order to determine the distribution of LA (and visible vermiculite) along roadway ROWs. This information was used to, among other things, determine whether air sampling (activity-based sampling (ABS); See section 3.1.2) was performed over a range of surface soil LA levels and visible vermiculite conditions.

In general, one soil aliquot was collected for every 100 ft of ROW. The aliquots were originally to be collected in locations of visible vermiculite. However, this biased sampling was not performed in most areas due to the absence of visible vermiculite in all locations except for SH37 from Rainy Creek Road to the dam.

In most cases, one composite soil sample was created from the ten aliquots collected for every 1,000 ft of ROW. However, composite samples were created from as many as 30 to as few as 3 aliquots in sections of ROW where hard surfaces comprise much of the ROW. A total of 485 field (non-QC) composite soil samples were collected from July 7 to September 10, 2010.

Soil sample locations were recorded at the midpoint of each 1,000 foot segment of ROW from which each composite sample was collected. The locations of all composite samples are shown on Figure 3-1.

In addition to soil samples collected during 2010, composite samples consisting of three aliquots were collected in 2003 and 2005 (CDM, 2005) and referred to as "Legacy Data" throughout the remainder of this report. The Legacy Data were collected only between Libby and Rainy Creek Road along SH 37 and are not shown on Figure 3-1. However, the analytical results from these samples are presented and discussed in Section 5.0.

3.1.2 Air Samples

All air samples were collected by drawing a sample through a filter that traps asbestos and other particulate material on the face of the filter. Two main categories of air samples were collected:

1. Personal Air Samples - Sampling equipment worn by a person or affixed to operating equipment/vehicle.

2. Stationary Air Samples - Sampling equipment placed on a motionless surface.

Personal air sampling involved a variety of activities performed by the sampler generally involving operation of recreational or roadway maintenance equipment/vehicles. Such sampling is referred to in the remainder of this report as Activity-Based Sampling (ABS).

Air sampling for asbestos was conducted using Emergency Response Team (ERT) SOP #2015, *Asbestos Sampling.* The sampling train consisting of 0.8-micron (~m), 25-millimeter (mm) mixed cellulose ester (MCE) filter cassette connected to a sampling pump (Lockheed Martin, 2010b). For personal ABS sampling, participants were fitted with the appropriate sampling pump with the cassettes secured near the operator's breathing zone.

ABS Sampling:

For the 2010 and 2011 OU8 RI field program, these activities included:

Recreational Activities

- Riding ATVs with a lead and following ATV.

MDOT Maintenance Activities

- Rotomilling of asphalt pavement
- Grass cutting and brush hogging in rights-of-way

All ABS sampling during the 2010-2011 OU8 Field Program was conducted along SH37 between Libby and Rainy Creek Road (See Figure 3-1). This portion of roadway was selected for ABS (excluding rotomilling) based on the presence of LA and visible vermiculite in surface soils as determined during investigations conducted in 2003 and 2005 (CDM, 2005).

Rotomilling ABS sampling was performed along Hwy 37 as part of regularly scheduled maintenance work conducted by MDOT. The general area of interest (California Ave.) was selected because one of several core samples collected in California Ave. in March 2010 contained a trace (0.1%) of LA (Lockheed Martin, 2010a).

All ABS sampling other than rotomilling was performed in September or October in order to make measurements during the time of year where conditions are drier than most other months.

The effects of seasonal soil moisture has no effect on the results of asphalt rotomilling ABS sampling.

A summary of the ABS sampling procedures implemented during the 2010-2011 OU8 field program is provided below. Further details are provided in a QAPP (Lockheed Martin, 2010a) and ABS Trip Reports (Lockheed Martin, 2010b and 2011).

<u>Brush Hogging</u>

Brush hogging activities took place over three days in September 2010. This activity involved powered equipment using rotary blades similar to a large lawn-mower (tractor and implement) to cut shrubs and small tress along the roadway embankment. A total of seven activities (scenarios) took place at seven locations at a rate of two to three per day. Each scenario was between approximately 60 and 200 minutes. During each scenario four air samples were collected at varying air flow rates. Two samples were collected at the front of the unit (tractor and implement) and two samples were collected on the back of the unit. In addition, a 30-point composite soil sample was collected to represent the seven locations where the brush hogging ABS was performed.

<u>Grass Cutting</u>

One grass cutting activity (scenario) was conducted at two locations over the course of two days in September 2010. Each scenario was approximately 150 minutes and involved the collection of four air samples. Two samples were collected at the front of the unit (tractor and implement) and two samples were collected on the back of the unit (at varying air flow rates). In addition, a 30-point composite soil sample was collected to represent the two locations where the grass cutting ABS was performed.

<u>ATV Riding</u>

Eight ATV riding activities (scenarios) took place at four locations over the course of four days in September 2010. Each scenario involved a lead and following ATV and was performed twice at each location during approximately 120 minutes. The ATVs maintained their relative positions at a distance of approximately 50 to 75 ft throughout each scenario. Two sampling pumps were placed on the lead ATV and two sampling pumps were placed on the following ATV resulting in the collection of four samples per scenario (32 samples total). In addition, a 30-point composite soil sample was collected to represent the three locations where the off-road ATV ABS was performed. One of the ATV scenarios involved riding on a paved surface and no soil sample was collected for that event.

Rotomilling

Rotomilling activities took place over three days in April 2011. Personal air samples were limited to those collected from the moving rotomill and skid steer (a small front end loader).

A total of 10 field personal air samples were collected. Eight were collected from the rotomilling machine and two were collected from the skid steer.

Additional samples associated with rotomilling were stationary and are discussed below.

Stationary Air Samples:

Stationary sampling included ambient air proximal to a person or piece of equipment conducting ABS activities. Such stationary air samples were collected to represent conditions in the breathing zone as a surrogate for a personal air sample. These are referred to as perimeter samples and typically monitor the perimeter of an ABS activity involving equipment operation that mobilizes dust into the air.

For the 2011 OU8 Field Program the following types of stationary air sampling were conducted:

- At fixed locations on both sides of the street where rotomilling operations were conducted. The samplers formed an inner perimeter around the rotomill spaced about a block (approximately 300 ft) apart.
- At selected locations up to 1,000 ft from California Ave., comprising an outer perimeter (also referred too as ambient air samples in the QAPP; Lockheed Martin, 2010a). These outer perimeter samples were initiated at the beginning of the day and completed at the end of each work day.

Overall, 76 stationary field air samples were collected at 38 locations (See Figure 3-2).

3.1.3 Quality Control Samples

Quality control samples type and collection frequency included:

Soil Samples

- Field duplicate soil samples were collected at a rate of one duplicate sample per 20 soil samples collected.
- Soil sample field blanks (blank sand) were collected at a rate of one field blank sample per 20 soil samples.

Air Samples

- One lot blank was analyzed for each new lot of MCE filter cassettes.

- One field blank was collected and submitted for analysis for each day of sampling for the duration of the ABS and rotomilling activities.
- Four perimeter field duplicates were collected and analyzed for each day of sampling (two collected at the high flow rate and two at the low flow rate).
- One ambient air field duplicate was collected over an 8-hour period at the high flow rate and analyzed each day for the duration of the rotomilling project.

An assessment of data quality is summarized in Section 4 and the full Data Quality Assessment (DQA) Report is provided as Appendix A.

3.2 SAMPLE PREPARATION AND ANALYSIS

3.2.1 Soil

Polarized Light Microscopy (PLM)

Soil samples collected as part of the OU8 sampling programs were prepared for analysis in accord with SOP ISSI-LIBBY-01 as specified in the CDM Close Support Facility (CSF) Soil Preparation Plan (CDM, 2004). In brief, each soil sample is dried and sieved through a ¼ inch screen. Particles retained on the screen (if any) are referred to as "coarse" fraction. Particles passing through the screen are referred to as fine fraction, and this fraction is ground by passing it through a plate grinder. Resulting material is referred to as "fine ground" fraction. The fine ground fraction is split into four equal aliquots; one aliquot is submitted for analysis and the remaining aliquots are archived at the CSF.

Soil samples are analyzed using PLM by visual estimation (PLM-VE) whereby the analyst visually estimates the amount of asbestos in the sample (expressed as percent by weight) based on comparison to reference materials.

The coarse fractions were examined using stereomicroscopy, and any particles of asbestos (confirmed by PLM) were removed and weighed in accord with SRC-LIBBY-01 (referred to as "PLM-Grav"). Fine ground aliquots were analyzed using a Libby-specific PLM method using visual area estimation, as detailed in SOP SRC-LIBBY-03. For convenience, this method is referred to as "PLM-VE."

PLM-VE is a semi-quantitative method that utilizes site-specific LA reference materials to allow assignment of fine ground samples into one of four "bins," as follows:

- *Bin A (ND):* non-detect
- *Bin B1 (Trace):* detected at levels lower than the 0.2% LA reference material
- *Bin B2 (<1%):* detected at levels lower than the 1% LA reference material but higher than the 0.2% LA reference material

- *Bin C:* LA detected at levels greater than or equal to the 1% LA reference material

Visual Inspection

For soil samples, field teams also provide a semi-quantitative estimate of visible vermiculite present at soil sampling point(s). Visual inspection data can be used to characterize the level of vermiculite (and presumptive LA contamination) in an area and considers both frequency and level of vermiculite. This is achieved by assigning a weighting factor to each level, where weighting factors are intended to represent relative levels of vermiculite in each category.

As presented in SOP CDM-LIBBY-06, guidelines for assigning levels are as follows:

- None – No flakes of vermiculite observed within the soil sample.
- Low – A maximum of a few flakes of vermiculite observed within the soil sample.
- Moderate – Vermiculite easily observed throughout the soil sample, including the surface and contains <50% vermiculite.
- High – Vermiculite easily observed throughout the soil sample, including the surface and contains 50% or more vermiculite.

Based on these descriptions, weighting factors used to characterize magnitude of LA occurrence in soil are as follows:

Visible Vermiculite Level (L_i)	Weighting factor (W_i)
None	0
Low	1
Moderate	3
High	10

The composite score is then the weighted sum of the observations for the area:

$$Score = \frac{\sum_{i=1}^{30} L_i * W_i}{30}$$

This value can range from zero (all 30 points are “none”) to a maximum of 10 (all 30 points are “high”). For example, an ABS area with 1 “low” point and 29 “none” points would receive a value of 1/30 = 0.033, while an ABS area with 24 “intermediate” points and 5 “high” would receive a score of (24·3 + 5·10) / 30 = 4.13.

In addition to the visual estimation method described above, field crews used a less sophisticated technique prior to implementation of SOP CDM-LIBBY-06 in 2006. This involved noting in the field the simple presence or absence of visible vermiculite in soil samples.

3.2.2 Air

In the past, the most common technique for measuring asbestos in air was phase contrast microscopy (PCM). In this technique, air is drawn through a filter and airborne particles become deposited on the face of the filter. All structures that have a length greater than 5 micrometers (μm) and have an aspect ratio (the ratio of length to width) of 3:1 or more are counted as PCM fibers. The limit of resolution of PCM is about 0.25 um, so particles thinner than this are generally not observable.

A key limitation of PCM is that particle discrimination is based only on size and shape. Because of this, it is not possible to classify asbestos particles by mineral type, or even to distinguish between asbestos and non-asbestos particles. For this reason, nearly all samples of air collected in Libby are analyzed by transmission electron microscopy (TEM).

This method operates at higher magnification (typically about 20,000x) and hence is able to detect structures much smaller than can been seen by PCM. In addition, TEM instruments are fitted with accessories that allow each particle to be classified according to mineral type.

Air samples filters were directly prepared for analysis by TEM in accord with preparation methods provided in International Organization for Standardization (ISO) 10312 (ISO, 1995). In the case where filter cassettes were found to be overloaded, the filters were prepared for analysis in accordance with SOP EPA-Libby-08 (indirect prep). This indirect preparation method was employed for three samples associated with brush hogging and two samples associated with rotomilling.

Sample analysis was by TEM in basic accord with counting and recording rules specified in ISO 10312, and certain project-specific counting rule modifications including changing the recording rule to include structures with an aspect ratio ≥ 3:1.

For each countable structure particle identified, the analyst records structure-specific information (e.g., length, width, asbestos mineral type) which is then used to calculate air concentration in LA structures per cubic centimeter (s/cc).

4.0 DATA RECORDING, DATA QUALITY ASSESSMENT, AND DATA SELECTION

4.1 DATA RECORDING

All analytical results are stored and maintained in the OU8 Scribe Database. A copy of the database is available through EPA Region 8 records center (See Appendix B).

Standardized data entry spreadsheets (electronic data deliverables or EDDs) have been developed specifically for the Libby project to ensure consistency between laboratories in the presentation and submittal of analytical data. In general, a unique EDD has been developed for each type of analytical method. Each EDD provides the analyst with a standardized laboratory bench sheet and accompanying data entry form for recording analytical data. Data entry forms contain a variety of built-in quality control functions that improve accuracy of data entry and help maintain data integrity. These spreadsheets also perform automatic computations of analytical input parameters (e.g., sensitivity, dilution factors, and concentration), thus reducing the likelihood of analyst calculation errors.

Asbestos analytical data (soil and air) was reported by the analytical laboratory in the form of an EDD and a pdf of the Data Report via email. All asbestos analytical data was then uploaded into the OU8 Scribe Database by the Environmental Services Assistance Team (ESAT - EPA's contractor) Data Manager.

Hard copies of all analytical reports are stored in the Scientific, Engineering, Response and Analytical Services (SERAS – EPAs contractor) Program Central Files and electronic copies are stored on SERAS Local Area Network.

All sampling location identification numbers were given to EPA's Environmental Response Team (ERT – EPA technical experts) by ESAT prior to the sampling event. Field sampling data were recorded for each sample collected by ERT personnel on a sample log sheet and loaded into the OU8 Scribe Database. All samples and copies of sample log sheets were delivered to the EMSL/Libby laboratory. ERT/SERAS prepared all COC forms prior to delivery of the samples to the laboratory.

Hard copies of all FSDSs, field log books, and COC forms generated during the OU8 sampling program were transferred to the Sample Receiving Coordinator at CDMs Libby Montana Project Office.

4.2 DATA QUALITY ASSESSMENT

DQA is the process of reviewing existing data to establish the quality of the data and to determine how any data quality limitations may influence data interpretation (EPA, 2006). The full DQA is provided as Appendix A and a summary is provided below.

A verification of a minimum of 10% of the TEM results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with SOP EPA-LIBBY-09 (rev 1). No discrepancies were discovered upon review of the original hand-written laboratory bench sheets to determine if the raw structure data were recorded in accord with ISO 10312 counting rules and SAP stopping rules. In addition, no errors were discovered when checks were performed to ensure that the data from the bench sheet were transferred into the OU8 Scribe Database without error or omission.

A verification of a minimum of 10% of the PLM-VE results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with draft SOPs for PLM verification. A review of the original laboratory PLM bench sheets and verification of the transfer of results from the bench sheets into the OU8 Scribe Database was performed. Because the issues identified are not likely to impact data interpretation, no future verification of PLM-VE results was recommended.

A verification of FSDS information for all 62 analyses selected for PLM-VE and TEM verification was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11. Several issues were discovered, some with the potential to impact data interpretation. The main issues involve discrepancies in the visible vermiculite information (number of aliquots vs. number of visible vermiculite observations) and sample date as well as omission of detailed pump information.

Discrepancies in the number of aliquots associated with visible vermiculite observations were limited to 4 samples out of 508. These visible vermiculite results (associated with sample HW-00129, HW-00130, HW-00133 and HW-0082) have been omitted from the remainder of the RI report.

In addition, the DQA explains that detailed pump information was examined on the original FSDS and that the issue was limited to the lack pump information in the OU8 Scribe Database.

4.3 DATA SELECTION

Raw data for samples utilized in describing the occurrence of LA in OU8 soils and air (Section 5) were obtained via a subscription to the OU8 Scribe Database through Scribe.net. A copy of this database was obtained by HDR, Inc. on December 16, 2012. A copy of the database is available through EPA Region 8 records center (See Appendix B).

Scribe queries were written to sort data by media, analytical method and to exclude quality control samples. The data set resulting from execution of the queries (excepting the four visible vermiculite results discussed in Section 4.2) was used to describe the nature and extent of LA occurrence.

5.0 NATURE AND EXTENT OF LA

5.1 CONTAMINANTS OF CONCERN

The contaminant of concern at the Libby Site is asbestos. Asbestos is the generic name for the fibrous form of a broad family of naturally occurring poly-silicate minerals. Based on crystal structure, asbestos minerals are usually divided into two groups - serpentine and amphibole.

- <u>Serpentine</u> - The only asbestos mineral in the serpentine group is chrysotile. Chrysotile is the most widely used form of asbestos, accounting for about 90% of the asbestos used in commercial products (IARC, 1977). There is no evidence that chrysotile occurs in the Libby vermiculite deposit, although it may be present in some types of building materials in Libby.
- <u>Amphibole</u> – Five minerals in the amphibole group that occur in the asbestiform morphology have found limited use in commercial products (IARC, 1977), including actinolite, amosite, anthophyllite, crocidolite, and tremolite.

At the Libby Site, the form of asbestos that is present in the vermiculite deposit is amphibole asbestos that for many years was classified as tremolite/actinolite (McDonald et al., 1986a, Amandus and Wheeler, 1987). More recently, the U.S. Geological Service performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from asbestos veins at the mine (Meeker et al., 2003). Using mineralogical naming rules recommended by Leake et al. (1997), the results indicate that asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, magnesioriebeckite and possibly actinolite.

Because mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because EPA does not find that there are toxicological data to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as LA.

5.2 LA IN SOIL

Surface Soil

Figure 5-1 illustrates LA occurrence in OU8 surface soils based on PLM results. A 4-color scheme is used to indicate the amount of LA present in a sample (additional detail on analytical reporting is provided in Appendix C):

- green = Bin A (non-detect)
- yellow = Bin B1 (trace)
- orange = Bin B2 (< 1%)
- red = Bin C (≥ 1%)

In this figure, composite samples collected during the 2010 field program are plotted as circles. Composite samples collected in 2003 and 2005 and referred to as "Legacy Data" are plotted as triangles (CDM, 2005). The Legacy Data was collected only between Libby and Rainy Creek Road along SH 37.

Of the 485 non-QC field composite samples, one (HW-00376) has no geographic information associated with it. Therefore, it is excluded from Figure 5-1. This sample contained no detectable LA.

Figure 5-2 illustrates vermiculite occurrence in surface soils based on visible vermiculite observations which utilized a semi-quantitative approach. Results are shown as squares and are color-coded based on the visible score (see Section 3.2.1):

- green = score of 0 (no visible vermiculite detected)
- yellow = score < 0.1
- orange = score 0.1 to < 0.3
- red = score > 0.3

One potential limitation to the approach for presenting visible score data is that the choice of cut-offs for use in color-coding is arbitrary. If other cut-offs were chosen, the appearance of the figures would be different. For example, the cutoff for red is 0.3 out of a possible score of 10. Nevertheless, the figures do provide a useful indication of the degree to which there is variation across OU8 and locations where higher than average levels have been observed.

Soil PLM results are generally ND to trace except between Libby and Rainy Creek Road where results are trace to <1% with a few NDs. Relatively higher levels of LA in surface soils between Libby and the Rainy Creek Road is expected as ore trucks traveled this route during operation of the mine.

Visible vermiculite is limited to soil samples collected from the section of SH 37 east of Rainy Creek Road. This result is unexpected given that soil samples from this area (analyzed by PLM) contained detectable LA at a frequency that is not elevated relative to the rest of OU8 (Figure 5-1).

The lack of visible vermiculite in soil samples collected between Libby and Rainy Creek Road is also unexpected given that soil samples from this area (analyzed by PLM) contained detectable LA at a frequency that is elevated relative to the rest of OU8 (Figure 5-1). Contrary to these findings (from the 2010 data set), vermiculite was observed in surface soils along this portion SH 37 in 2003 and 2005 (CDM, 2005).

Spatial variability may account for some of the differences in the level of visible vermiculite across sample events. Other differences likely arise from the inherently subjective nature of vermiculite level category assignments, as well as variations in site conditions between rounds (e.g., cloud cover vs. sunshine, amount of ground cover, soil moisture, etc.).

5.3 LA IN AIR

ABS Air

The amount of LA fibers released to air will vary depending upon the level of LA in the source material (e.g., outdoor soil) and the intensity and duration of the disturbance activity. Because of this, predicting the LA levels in air associated with disturbance activities based only on measured LA levels in the source material is extremely difficult. Therefore, ABS is considered to be the most direct way to estimate potential exposures from inhalation of asbestos. ABS results for ATV riding, brush hogging and grass cutting are presented on Figure 5-3. ABS results for rotomilling are presented on Figure 5-4.

As seen on Figure 5-3, LA was not detected in air during grass cutting activities. However, LA was detected during ATV riding and brush hogging. Concentrations associated with these activities ranged between <0.0020 LA s/cc to 0.0180 s/cc. As discussed in Section 3.1.1, the area over which these ABS activities were performed was selected based on the presence of LA and visible vermiculite in surface soils during the 2003 and 2005 sample event (CDM, 2005).

As seen on Figure 5-4, LA was not detected in air samples collected from the rotomilling machine and skid steer (small front-end loader). Detection limits ranged from 0.0216 s/cc to 0.0025 s/cc.

Based on the surface soil PLM results (Section 5.2), the ABS air sampling was performed in that portion of OU8 with the highest levels of LA in soil. This suggests that the ABS air samples discussed in this section represents the worst case condition in the entire OU.

Stationary Air

As discussed in Section 3.1.2, stationary sampling included ambient air proximal to a person or piece of equipment conducting ABS activities. Such stationary air samples were collected to represent conditions in the breathing zone as a surrogate for a personal air sample (e.g., a person walking on the sidewalk during rotomilling operations on the adjacent street).

For the 2011 OU8 Field Program the following types of stationary air sampling were conducted:

- At fixed locations on both sides of the street where rotomilling operations were conducted. The samplers formed an inner perimeter around the rotomill spaced about a block (approximately 300 ft) apart.
- At selected locations up to 1,000 ft from California Ave., comprising an outer perimeter (also referred too as ambient air samples in the QAPP; Lockheed Martin, 2010a).

As seen on Figure 5-5, LA was detected in 1 of 52 inner perimeter field samples at a concentration of 0.0030 s/cc. Detection limits ranged from 0.0017 s/cc to 0.0247 s/cc.

As seen on Figure 5-6, LA was not detected in any outer perimeter (ambient) sample. Detection limits ranged from 0.0007 S/cc to 0.0.0010 s/cc.

6.0 CONTAMINANT FATE AND TRANSPORT

The source for LA detected in surface soils and an air sample associated with rotomilling may include:

- Vermiculite ore released from ore trucks by wind or other means during transport along state and local highways.
- Imported fill containing vermiculite mine wastes used during earthwork for roadway construction or maintenance.
- Naturally occurring LA (at background levels) in native soils in roadway ROW.
- Aggregate containing vermiculite mine wastes used to manufacture asphalt.
- Naturally occurring LA (at background levels) in aggregate used to manufacture asphalt.

Natural background levels of LA at the Site have not been established, although a study is underway that attempts to do this. Nevertheless, the relatively low levels and uniform distribution of LA in soils in roadway ROWs (excepting the portion of SH 37 between Libby and Rainy Creek Road), precludes elimination of natural background conditions as responsible for some of the LA detected in OU8.

The fate and transport of asbestos containing fibers is dependent on the type of host media (soil, water, air, etc.), land use, and site characteristics. Asbestos fibers (both serpentine and amphibole) are indefinitely persistent in the environment. According to the Agency for Toxic Substances and Disease Registry (ATSDR):

> *"Asbestos fibers are nonvolatile and insoluble, so their natural tendency is to settle out of air and water, and deposit in soil or sediment (EPA 1977, 1979c). However, some fibers are sufficiently small that they can remain in suspension in both air and water and be transported long distances. For example, fibers with aerodynamic diameters of 0.1–1 μm can be carried thousands of kilometers in air (Jaenicke 1980), and transport of fibers over 75 miles has been reported in the water of Lake Superior (EPA 1979c)."* In addition, *"they are resistant to heat, fire, and chemical and biological degradation"* (ATSDR, 2001).

The primary transport mechanisms for asbestos and asbestos containing material include:

- Suspension in air and transport via dispersion
- Suspension in water and transport downstream

Asbestos can become suspended in air when asbestos or asbestos containing material is disturbed. Wind, recreational activities, construction, and site work can disturb material outdoors.

Asbestos residence time in the air is determined primarily by particulate thickness; however it is influenced by other factors such as length and static charge. The average thickness of LA particles is 0.4 µm and ranges from approximately 0.1 to 1.0 µm. The suspension of LA in air is measured in “half times” which is the amount of time it will take 50% of LA particles to settle out of the air column. A particle with a thickness of 0.5 µm has a half time of approximately two hours, assuming the source of disturbance has been removed (CDM, 2009).

Larger particles will settle faster; a particle of 1 µm has a half time of about 30 minutes. Smaller LA particles may stay suspended for significantly longer. The typical half time for a 0.15 particle is close to 40 hours (CDM, 2009)

Activity-specific testing found that the half-time of LA suspended by dropping vermiculite on the ground was about 30 minutes. LA suspended from disturbing vermiculite insulation settled within approximately 24 hours (CDM, 2009).

Once suspended, LA moves by dispersion through air. LA concentration will be highest near the source and will decrease with increasing distance. In outdoor air, wind speed will determine direction and velocity of LA particle transport. Wind can cause the rapid dispersal of LA from the source of release.

In water, LA particles can be transported downstream with the current. As in air, larger particles tend to settle to the bottom more rapidly than smaller particles. Settled particles may be transported downstream with sediment (CDM, 2009).

LA is insoluble and therefore transport in solution will not occur in surface water, groundwater or from soils to water. Further, as a particle, LA is not expected to be mobilized from surface or near surface soils vertically through the soil column to the water table.

7.0 HUMAN HEALTH RISK ASSESSMENT

An evaluation of potential exposures to and risks from LA will be included in the site-wide risk assessments for the Libby Asbestos Superfund Site. Site-wide risk assessments are stand-alone documents which support the FS and ROD. As such, OU-specific risk assessment reports have not been developed.

The *Site-Wide Human Health Risk Assessment* will evaluate potential risks to humans from exposures to LA under a variety of different exposure scenarios, including both indoor and outdoor exposure scenarios that may occur at the Site. Potential risks will be evaluated both alone and across multiple exposure scenarios as part of a cumulative exposure assessment.

The *Site-Wide Ecological Risk Assessment* will evaluate potential risks to aquatic and terrestrial ecological receptors from exposures to LA that may be present in the environment at the Site.

Refer to the respective site-wide risk assessment reports to provide information on potential exposures and risks from LA to human and ecological receptors.

8.0 CONCLUSIONS

The RI reached the following general conclusions:

1. Approximately 80% of PLM results for surface soil samples collected as part of the OU8 RI field program are non-detect (ND) with the remainder containing trace amounts of LA. Some soil samples collected prior to the establishment of OU8 (legacy data) between the Libby Mine (Rainy Creek Road) and the town of Libby contained LA at levels between trace and 1%. Relatively higher levels of LA in surface soils between Libby and the Rainy Creek Road are expected as ore trucks traveled this route during operation of the mine.

2. Visible vermiculite is limited to the section of SH 37 east of Rainy Creek Road. This result is somewhat unexpected given that frequency of LA detections in soil samples in this area is not elevated relative to the rest of OU8.

3. Predicting LA levels in air associated with disturbance activities based only on measured LA levels in soil is extremely difficult. Therefore, ABS is considered to be the most direct way to estimate potential exposures from inhalation of asbestos.

4. Exposure pathways that are thought to be most likely of potential concern in OU8 include exposure of ATV riders along roadway ROW and exposure of outdoor roadway maintenance workers performing grass cutting, brush hogging and rotomilling.

5. ABS air sampling was conducted to assess exposure to roadway maintenance workers and ATV riders. Air sampling pumps were affixed to ATVs and maintenance equipment during ABS sample events.

6. Air sampling associated with rotomilling also involved fixed sampling stations on both sides of the street where rotomilling operations were conducted (forming an inner perimeter). In addition, stationary air samples were collected at various locations up to 1,000 ft from the rotomill, comprising an outer perimeter.

7. An evaluation of potential exposures to and risks from LA will be included in the site-wide risk assessments for the Libby Asbestos Superfund Site. Site-wide risk assessments are stand-alone documents which support the FS and ROD

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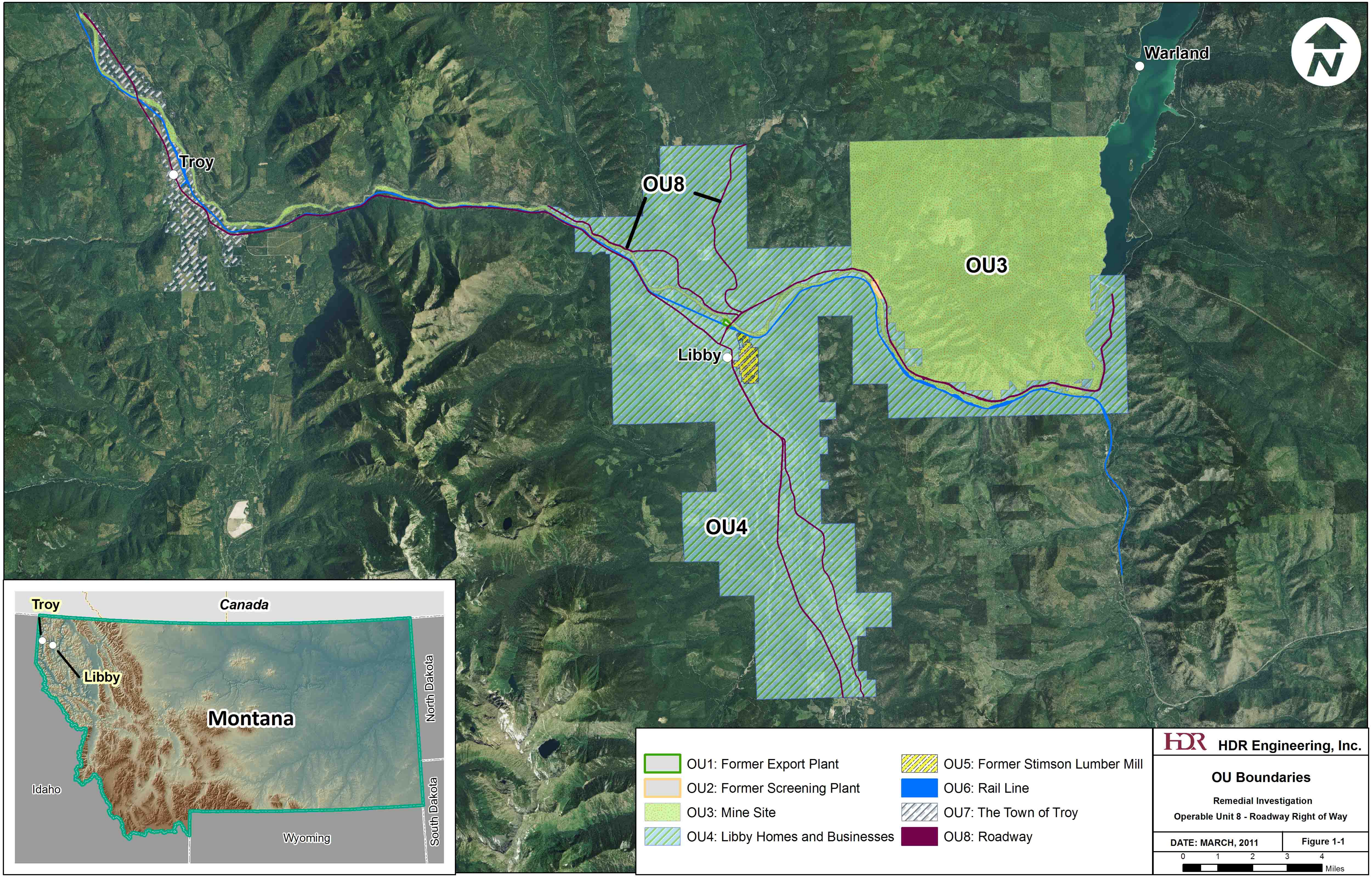
Tables

TABLE 3-1
Sampling Events Relevant to OU8

Location	Date	Investigation Description	Media Collected and Analyzed	Reason for Selecting Sample Location	Reference
Montana State Highway 37	2001	Exposures to cleanup workers and highway users during remediation activities	Air associated with vehicle and foot traffic	Opportunistic air sampling (sampler affixed to personnel and vehicles)	CDM, 2005
Montana State Highway 37	2003	Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4	Surface soil (0-6") composite samples	Systematic surface soil sampling	CDM, 2005
Montana State Highway 37	2005	To resample the 2003 locations in the 0-1" interval	Surface soil (0-1") composite samples	Co-locate with 2003 locations.	CDM, 2005
Montana State Highway 37	2005	Assess exposure to individuals working on or near Hwy 37	Stationary air samples	Systematic air sampling along the same portion of Hwy 37 that was subjected to soil sampling in 2003	CDM, 2005
MDT Rights-of-Way within 5-miles of Libby	2006	Assessment to support MDT Industrial Hygene Policy	Activity-Based Air Samples (ABS) associated with MDT maintenance activities Traction sand and road aggregate Road sweepings Surface soil grab samples	Opportunistic air sampling (sampler affixed to personnel and equipment);opportunistic traction sand and aggregate sampling ; random road sweeping sampling; systematic soil sampling	Tetra Tech, Inc, 2007 a
Montana State Highway 37	2007	Assessment to support MDT Industrial Hygene Policy	ABS air samples associated with MDT maintenance activities	Opportunistic air sampling (sampler affixed to personnel and equipment)	Tetra Tech, Inc., 2007 b
OU8 State and Local Highway embankement	2010	Remedial Investigation Field Program	ABS Air samples asscoiated with recreational and MDT embankement maintenance activities; surface soil composite samples	ABS air samples collected between Libby and Rainy Creek Road (location along Hwy 37 where LA was detected during 2005 soil sample event); systematic soil sampling throughout OU8	EPA Scribe Database
OU8 State and Local Highway pavement	2011	Remedial Investigation Field Program	ABS Air samples associated with pavement rotomilling activities	Oppotunistic air sampling	EPA Scribe Database

Figures


Warland
Troy
OU8
OU3
Libby
OU4
Troy
Canada
Libby
Montana
North Dakota
Idaho
South Dakota
Wyoming
OU1: Former Export Plant
OU2: Former Screening Plant
OU3: Mine Site
OU4: Libby Homes and Businesses
OU5: Former Stimson Lumber Mill
OU6: Rail Line
OU7: The Town of Troy
OU8: Roadway
HDR Engineering, Inc.
OU Boundaries
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MARCH, 2011
Figure 1-1
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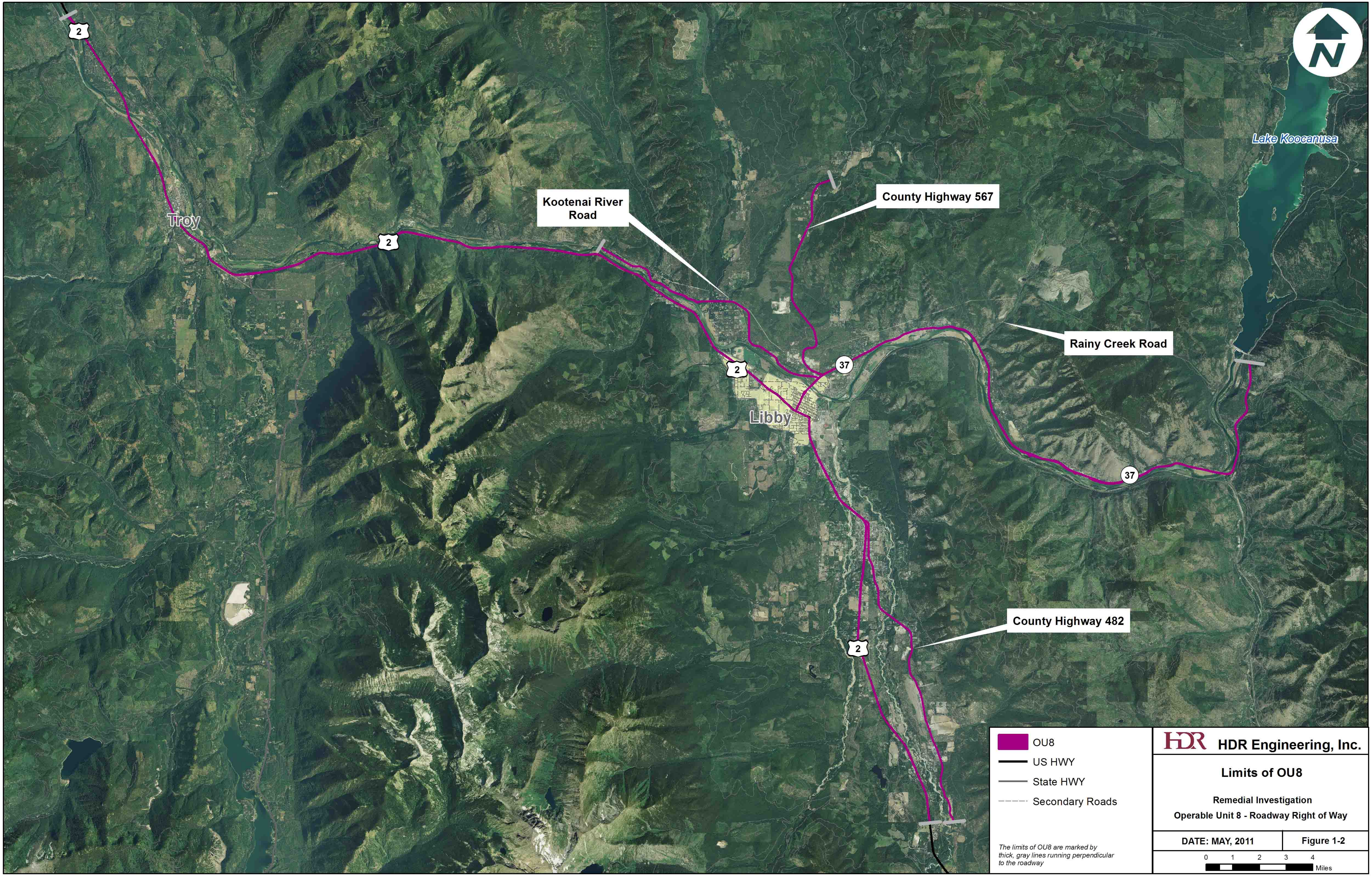
Miles



OU8	
US HWY	
State HWY	
Secondary Roads	

The limits of OU8 are marked by thick, gray lines running perpendicular to the roadway

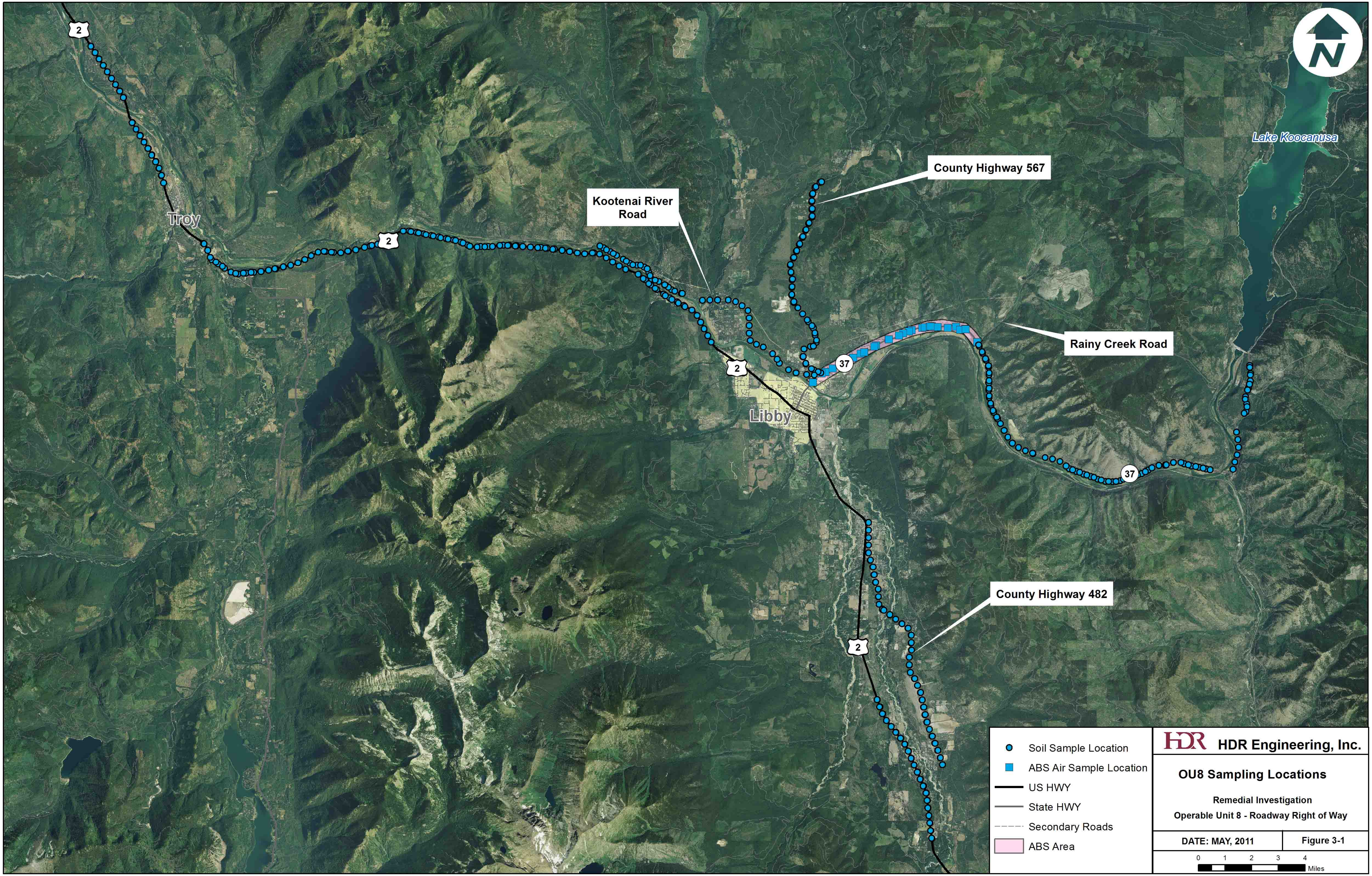
HDR Engineering, Inc.

Limits of OU8

Remedial Investigation
Operable Unit 8 - Roadway Right of Way

DATE: MAY, 2011 | **Figure 1-2**

0 1 2 3 4 Miles



2
Troy
2
Kootenai River Road
County Highway 567
Lake Koocanusa
Rainy Creek Road
37
2
Libby
37
County Highway 482
2
N
Soil Sample Location
ABS Air Sample Location
US HWY
State HWY
Secondary Roads
ABS Area
HDR Engineering, Inc.
OU8 Sampling Locations
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MAY, 2011
Figure 3-1
0 1 2 3 4
Miles

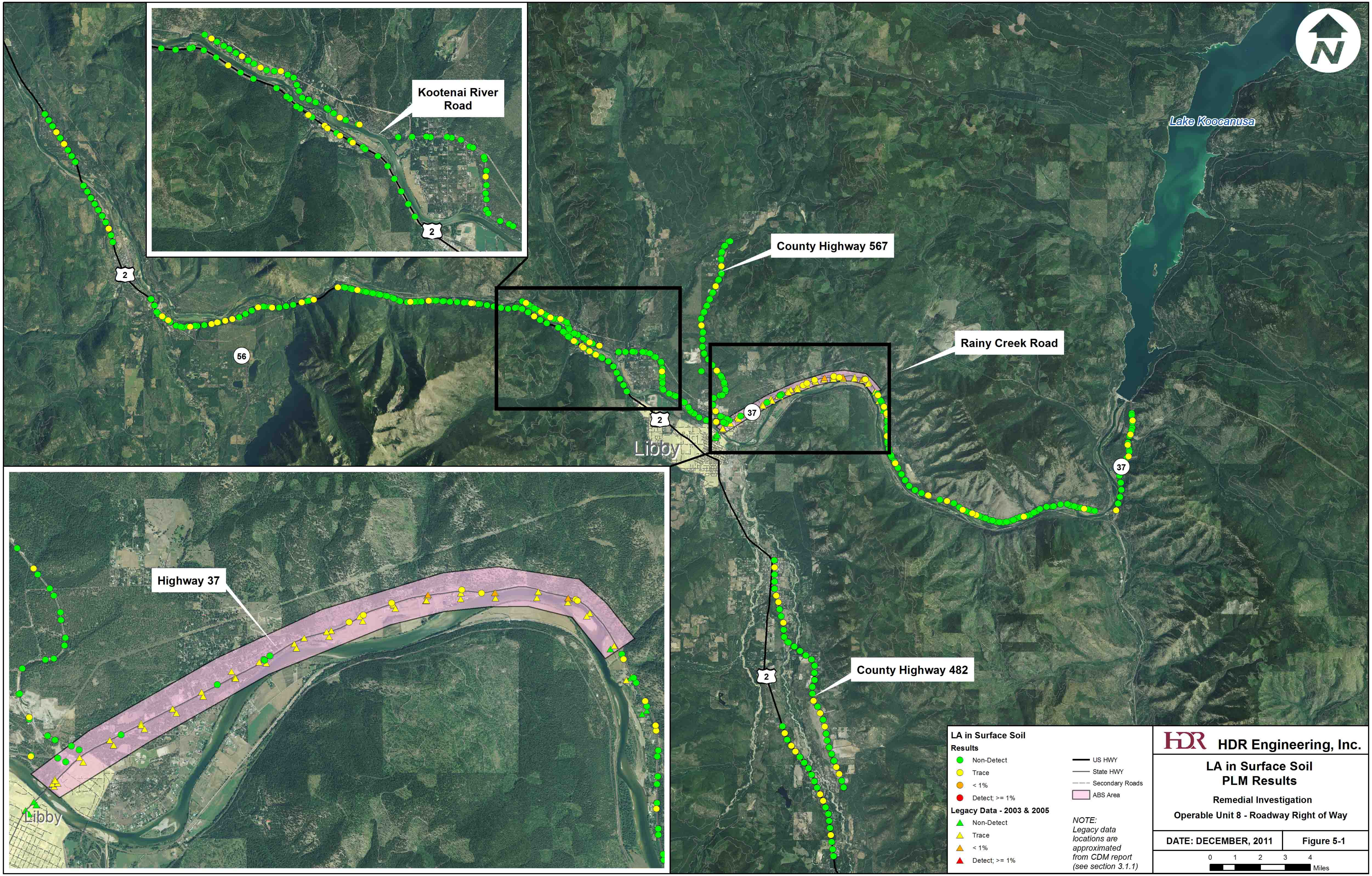
HDR Engineering, Inc.

Inner and Outer-Perimeter Air Sample Locations

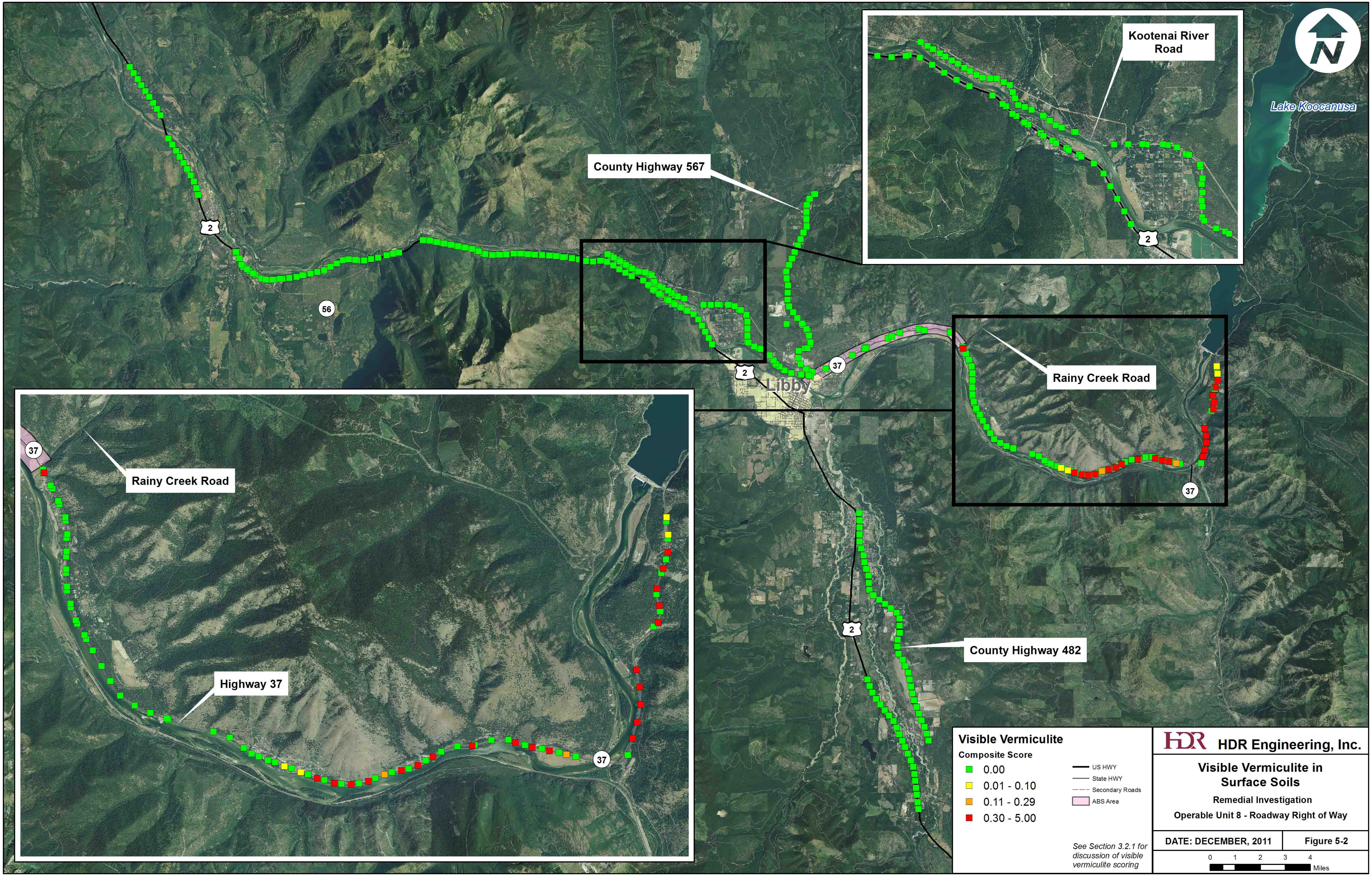
Remedial Investigation

Operable Unit 8 - Roadway Right of Way

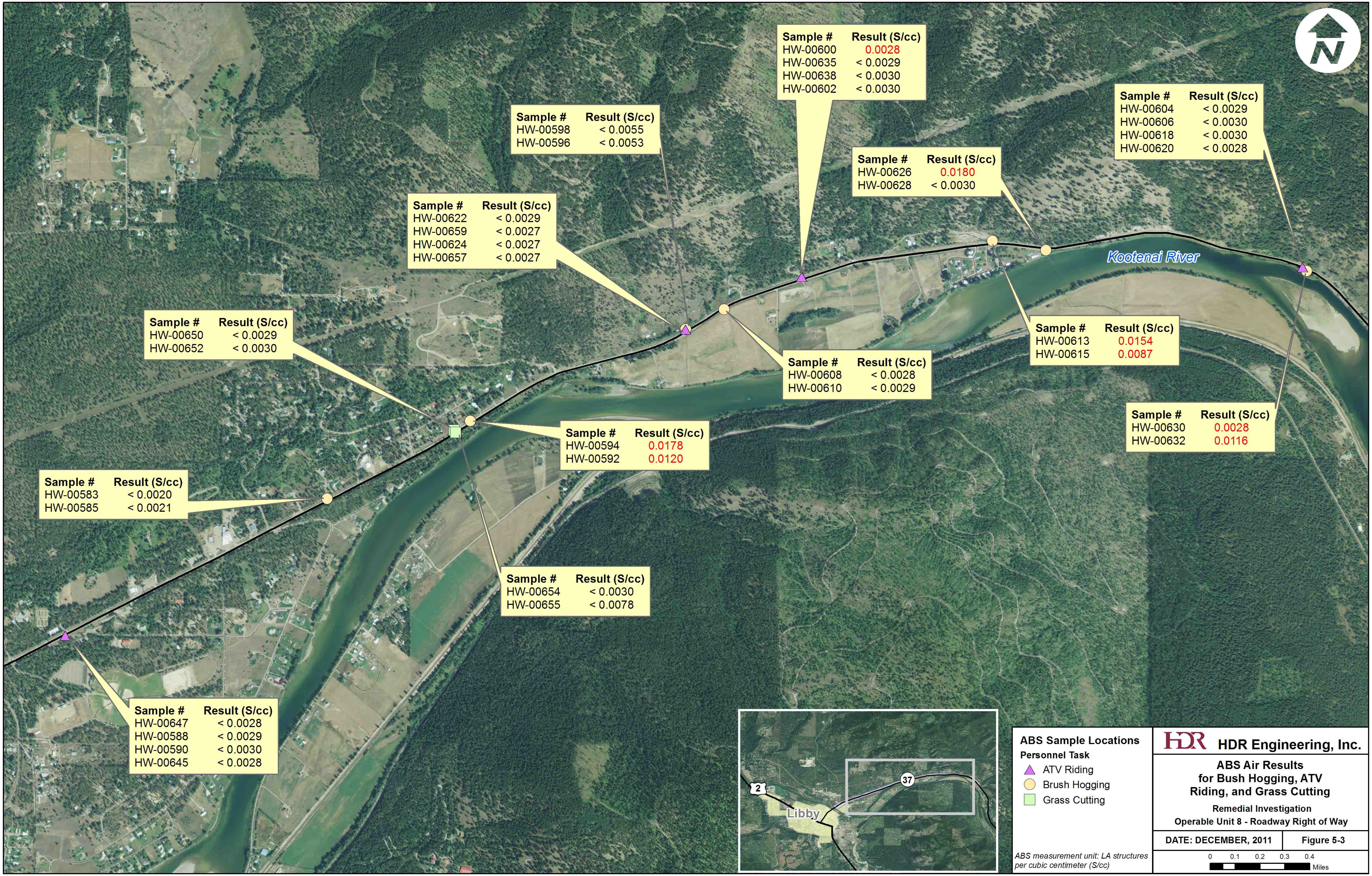
DATE: DECEMBER, 2011	Figure 3-2

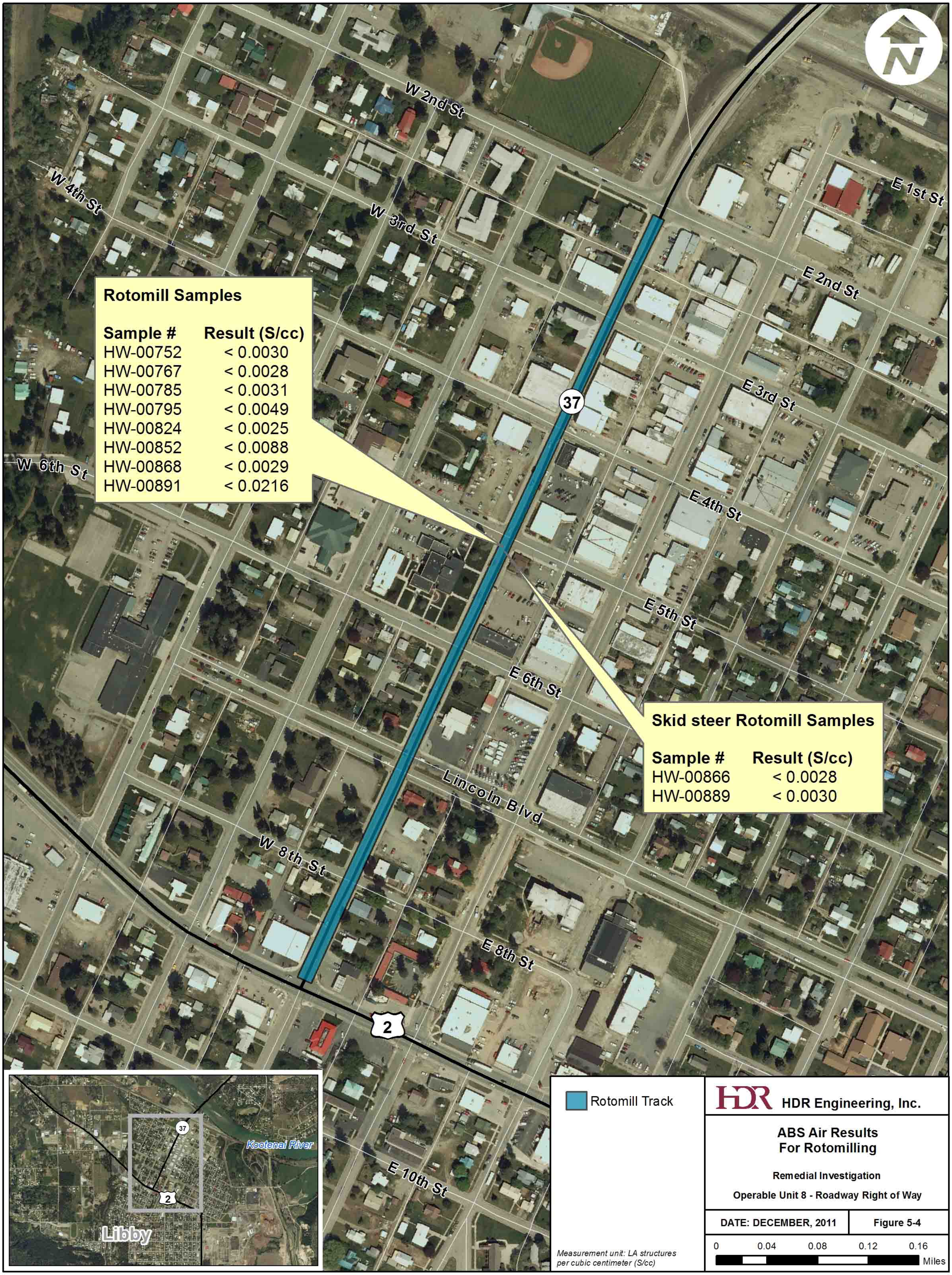


Kootenai River Road
County Highway 567
Lake Koocanusa
Rainy Creek Road
Highway 37
County Highway 482
Libby
2
37
56
N
LA in Surface Soil
Results
Non-Detect
Trace
< 1%
Detect; >= 1%
Legacy Data - 2003 & 2005
Non-Detect
Trace
< 1%
Detect; >= 1%
US HWY
State HWY
Secondary Roads
ABS Area
NOTE:
Legacy data locations are approximated from CDM report (see section 3.1.1)
HDR Engineering, Inc.
LA in Surface Soil
PLM Results
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-1
0 1 2 3 4
Miles

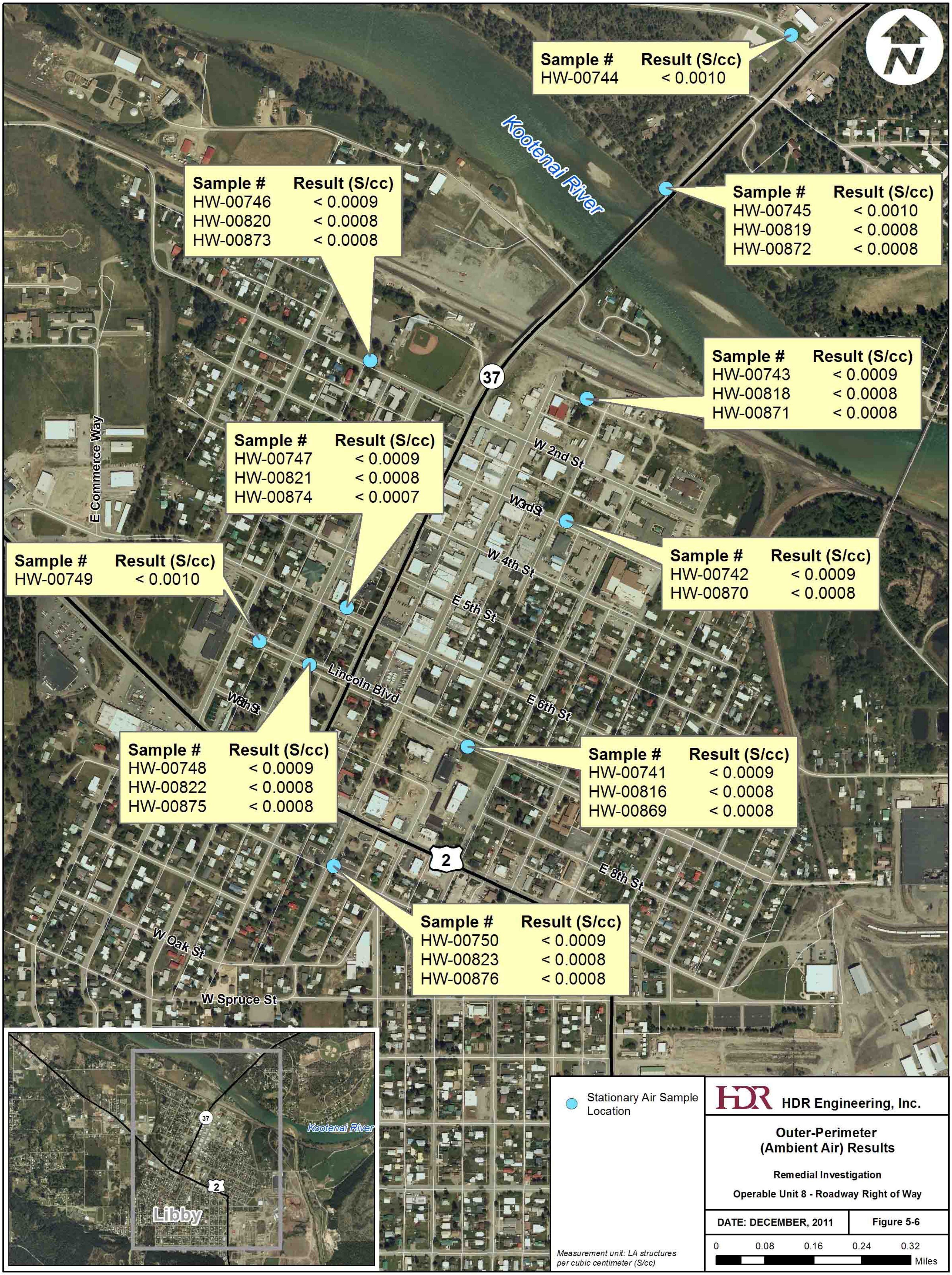


Kootenai River Road
Lake Koocanusa
County Highway 567
Rainy Creek Road
Highway 37
County Highway 482
Libby
Visible Vermiculite
Composite Score
0.00
0.01 - 0.10
0.11 - 0.29
0.30 - 5.00
US HWY
State HWY
Secondary Roads
ABS Area
See Section 3.2.1 for discussion of visible vermiculite scoring
HDR Engineering, Inc.
Visible Vermiculite in Surface Soils
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-2
0 1 2 3 4
Miles


Sample # Result (S/cc)
HW-00600 0.0028
HW-00635 < 0.0029
HW-00638 < 0.0030
HW-00602 < 0.0030
Sample # Result (S/cc)
HW-00598 < 0.0055
HW-00596 < 0.0053
Sample # Result (S/cc)
HW-00604 < 0.0029
HW-00606 < 0.0030
HW-00618 < 0.0030
HW-00620 < 0.0028
Sample # Result (S/cc)
HW-00626 0.0180
HW-00628 < 0.0030
Sample # Result (S/cc)
HW-00622 < 0.0029
HW-00659 < 0.0027
HW-00624 < 0.0027
HW-00657 < 0.0027
Kootenai River
Sample # Result (S/cc)
HW-00650 < 0.0029
HW-00652 < 0.0030
Sample # Result (S/cc)
HW-00613 0.0154
HW-00615 0.0087
Sample # Result (S/cc)
HW-00608 < 0.0028
HW-00610 < 0.0029
Sample # Result (S/cc)
HW-00594 0.0178
HW-00592 0.0120
Sample # Result (S/cc)
HW-00630 0.0028
HW-00632 0.0116
Sample # Result (S/cc)
HW-00583 < 0.0020
HW-00585 < 0.0021
Sample # Result (S/cc)
HW-00654 < 0.0030
HW-00655 < 0.0078
Sample # Result (S/cc)
HW-00647 < 0.0028
HW-00588 < 0.0029
HW-00590 < 0.0030
HW-00645 < 0.0028
2
37
Libby
ABS Sample Locations
Personnel Task
ATV Riding
Brush Hogging
Grass Cutting
ABS measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
ABS Air Results for Bush Hogging, ATV Riding, and Grass Cutting
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-3
0 0.1 0.2 0.3 0.4
Miles


Rotomill Samples
Sample # Result (S/cc)
HW-00752 < 0.0030
HW-00767 < 0.0028
HW-00785 < 0.0031
HW-00795 < 0.0049
HW-00824 < 0.0025
HW-00852 < 0.0088
HW-00868 < 0.0029
HW-00891 < 0.0216
Skid steer Rotomill Samples
Sample # Result (S/cc)
HW-00866 < 0.0028
HW-00889 < 0.0030
W 2nd St
W 3rd St
W 4th St
W 6th St
W 8th St
E 1st St
E 2nd St
E 3rd St
E 4th St
E 5th St
E 6th St
Lincoln Blvd
E 8th St
E 10th St
37
2
N
Kootenai River
Libby
Rotomill Track
Measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
ABS Air Results For Rotomilling
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-4
0 0.04 0.08 0.12 0.16
Miles


Sample # Result (S/cc)
HW-00850 < 0.0029
HW-00888 < 0.0028
Sample # Result (S/cc)
HW-00783 < 0.0027
HW-00815 < 0.0029
Sample # Result (S/cc)
HW-00779 < 0.0025
HW-00811 < 0.0025
Sample # Result (S/cc)
HW-00781 < 0.0053
HW-00813 < 0.0034
Sample # Result (S/cc)
HW-00846 < 0.0025
HW-00884 < 0.0028
Sample # Result (S/cc)
HW-00777 < 0.0026
HW-00809 < 0.0026
Sample # Result (S/cc)
HW-00775 < 0.0027
HW-00807 < 0.0025
Sample # Result (S/cc)
HW-00844 < 0.0247
HW-00882 < 0.0029
Sample # Result (S/cc)
HW-00842 < 0.0027
HW-00880 < 0.0028
Sample # Result (S/cc)
HW-00848 < 0.0029
HW-00886 < 0.0028
Sample # Result (S/cc)
HW-00771 < 0.0029
HW-00803 < 0.0027
Sample # Result (S/cc)
HW-00773 < 0.0028
HW-00805 < 0.0027
Sample # Result (S/cc)
HW-00838 < 0.0026
HW-00864 < 0.0029
Sample # Result (S/cc)
HW-00840 < 0.0028
HW-00877 < 0.0030
Sample # Result (S/cc)
HW-00765 < 0.0023
HW-00799 < 0.0027
Sample # Result (S/cc)
HW-00801 < 0.0028
Sample # Result (S/cc)
HW-00836 < 0.0027
HW-00862 < 0.0030
Sample # Result (S/cc)
HW-00834 < 0.0017
HW-00860 0.0030
Sample # Result (S/cc)
HW-00763 < 0.0028
HW-00797 < 0.0030
Sample # Result (S/cc)
HW-00761 < 0.0030
HW-00793 < 0.0025
Sample # Result (S/cc)
HW-00832 < 0.0028
HW-00858 < 0.0030
Sample # Result (S/cc)
HW-00830 < 0.0024
HW-00856 < 0.0029
Sample # Result (S/cc)
HW-00759 < 0.0028
HW-00791 < 0.0029
Sample # Result (S/cc)
HW-00757 < 0.0027
HW-00789 < 0.0029
Sample # Result (S/cc)
HW-00828 < 0.0025
HW-00854 < 0.0030
Sample # Result (S/cc)
HW-00755 < 0.0030
HW-00787 < 0.0030
W 2nd St
W 3rd St
W 4th St
E Commerce Way
W 6th St
E 5th St
37
Lincoln Blvd
W 8th St
E 6th St
E 8th St
2
E 10th St
W Oak St
N
37
Kootenai River
Libby
2
Stationary Air Sample Location
Measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
Inner-Perimeter (ABS) Rotomilling Air Results
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-5
0 0.05 0.1 0.15 0.2
Miles



HDR Engineering, Inc.

Outer-Perimeter (Ambient Air) Results

Remedial Investigation

Operable Unit 8 - Roadway Right of Way

DATE: DECEMBER, 2011

Figure 5-6

Appendices

Appendix A
Data Quality Assessment

VERIFICATION SUMMARY REPORT

FOR OPERABLE UNIT 8

LIBBY ASBESTOS SUPERFUND SITE

(Based on Scribe database provided on 1/27/11)

Prepared for:

U.S. Environmental Protection Agency Region 8

1595 Wynkoop Street

Denver, Colorado 80202

Prepared by:

SRC, Inc.

Denver, CO

February 1, 2011

CONTENTS

ATTACHMENTS

TEM CONSISTENCY REVIEW AND DATA TRANSFER VERIFICATION REPORT

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 TEM Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of a minimum of 10% of the TEM results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with Standard Operating Procedure EPA-LIBBY-09 (rev 1). No discrepancies were discovered upon review of the original hand-written laboratory bench sheets to determine if the raw structure data were recorded in accord with ISO 10312 counting rules and SAP stopping rules. In addition, no errors were discovered when checks were performed to ensure that the data from the bench sheet were transferred into the Scribe Database without error or omission.

Recommendations for future review and verification: No future verification is recommended.

TEM-ISO 10312 SELECTION AND CONSISTENCY REVIEW RESULTS

Summary of available analyses:

Analyst, Lab	Number of TEM-ISO 10312 Analyses			Number of Analyses Selected for Review		
	Detect	Non-Detect	Total	Detect	Non-Detect	Total
E. Wyatt-Pescador, EMSL 27	8	26	34	2	2	4

	Goal	Actual
Selected Total	4	4
Selected Detects	2	2
Selected Non-Detects	2	2

Detailed summary of bench sheet consistency review –

Number of analyses reviewed: 4 (100% of total analyses selected)

If not all analyses could be reviewed, provide a brief explanation for why: N/A

Number of analyses with recording issues identified: 0 (0% of total analyses reviewed)

Types of recording issues identified (indicate the number of analyses):

_______ Reported structure types are inconsistent with ISO guidance

_______ Primary and/or total columns are not populated correctly

_______ NAM structures are recorded and not identified as non-countable

_______ Fibers recorded as countable do not meet aspect ratio criteria (LB-000016)

_______ Mineral class designation is missing or inconsistent

_______ Structure comments are inconsistent with LB-000066

_______ Structure comments are inconsistent with recorded data

_______ Structure attributes in the database do not match the bench sheet

Do the recording issues identified appear to be associated with a particular analyst or laboratory? Yes No

If yes, identify the analyst and/or laboratory: ____

DATA TRANSFER VERIFICATION RESULTS

Number of analyses verified[1]: 4 (100% of total analyses selected)

Number of analyses with data transfer issues identified: 0 (0% of total analyses reviewed)

Types of data transfer issues identified:

_______ Incorrect/missing information on analysis details (e.g., lab job number, analysis date, filter status)

_______ F-factor calculation is incorrect or inputs are missing

_______ Air volume or dust area reported by laboratory is inconsistent with field value

_______ Number of grid openings counted is incorrect

_______ Sensitivity calculation is incorrect or inputs are missing

_______ Total number of countable LA structures is incorrect

Do the data transfer issues identified appear to be associated with a particular analyst or laboratory? Yes No

If yes, identify the analyst and/or laboratory: ____

____

Comments: No errors were discovered in the verification process.

ISSUE RESOLUTION AND STATUS

No resolutions are required. Attachments 1a and 1b contain the analyses that were verified and the information that was verified. Attachment 1a contains the analytical and results information and Attachment 1b contains the raw structure information.

[1] Only those analyses that have passed the bench sheet consistency review are included in the data transfer verification.

PLM CONSISTENCY REVIEW AND DATA TRANSFER VERIFICATION REPORT

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 PLM-VE Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of a minimum of 10% of the PLM-VE results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with draft Standard Operating Procedure for PLM verification. A review of the original laboratory PLM bench sheets and verification of the transfer of results from the bench sheets into the Scribe Database was performed.

Recommendations for future review and verification: Because the issues identified are not likely to impact data interpretation, no future verification is recommended.

PLM-VE SELECTION AND CONSISTENCY REVIEW RESULTS

Summary of available analyses:

Analyst, Lab	Number of PLM-VE Analyses			Number of Analyses Selected for Review		
	Detect	Non-Detect (Bin A)	Total	Detect	Non-Detect (Bin A)	Total
A. Goncalves, ESATR8	11	102	113	2	11	13
N. Fischer, ESATR8	18	96	114	2	10	12
N. MacDonald, ESATR8	14	105	119	2	11	13
T. Oliver, ESATR8	44	144	188	5	15	20
Total	87	447	534	11 47	58	

	Goal	Actual
Selected Total	58	58
Selected Detects	11	11
Selected Non-Detects	47	47

Detailed summary of bench sheet consistency review –

Number of analyses reviewed: 58 (100% of total analyses selected)

If not all analyses could be reviewed, provide a brief explanation for why: ________________________________

____

Number of analyses with recording issues identified: 0 (0% of total analyses reviewed)

Do the recording issues identified appear to be associated with a particular analyst or laboratory? Yes No

If yes, identify the analyst and/or laboratory: ____

____

DATA TRANSFER VERIFICATION RESULTS

Number of analyses verified[1]: 58 (100% of total analyses selected)

Number of analyses with data transfer issues identified: 5 (8.6% of total analyses verified)

Types of data transfer issues identified:

6 analyses had incorrect/missing information on analysis details (e.g., lab job number, analysis date)

Do the data transfer issues identified appear to be associated with a particular analyst or laboratory? Yes No

If yes, identify the analyst and/or laboratory: N. Fisher (ESATR8)

Comments: The lab sample IDs in Lab Job Number A101383 require revision throughout the lab job. In addition, the initials for the analyst in Lab Job Number A101373, Lab Sample IDs A101373-6 through -10 are unclear. They appear to be "ND", not "NF". Clarification on the benchsheets is required.

ISSUE RESOLUTION AND STATUS

The issues discovered in the verification process are summarized in the comments above and in Table 1 provided below. In addition, Attachment 2 contains a list of all analyses that were verified and the information that was verified.

Table 1. Summary of Issues

SampleNo	Lab Job Number	Verification Notes
HW-00087	A101373	Analyst's initials require clarification.
HW-00121	A101383	Lab Sample IDs are incorrect on benchsheets.

[1] Only those analyses that have passed the bench sheet consistency review are included in the data transfer verification.

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 FSDS Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of the sample information for analyses selected for PLM-VE and TEM verification was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11. Several issues were discovered, some with the potential to impact data interpretation. The main issues discovered involve discrepancies in the visible vermiculite information and sample date as well as omission of detailed pump information.

Recommendations for future review and verification: Because some issues identified could potentially impact data interpretation, additional verification is at the discretion of the data managers.

FSDS SELECTION

A verification of all FSDS information for all 62 analyses selected for PLM-VE and TEM verification was performed.

DATA TRANSFER VERIFICATION RESULTS

Number of samples verified: 64 (100% of total analyses selected)

Number of samples with data transfer issues identified: 10 (15.6% of total samples verified)

Types of data transfer issues identified:

__1__ Sam ple Date

__3__ Location Type

__1__ LocationID

__3__ Location Description

__1__ Visible Vermiculite Information

__1__ Sam ple CompositeYN

__1__ Sam ple Aliquots

Comments: There were several data transfer issues that require clarification on the benchsheets and/or revision to the database. An inconsistency between the visible vermiculite information and the number of aliquots of the soil sample was one of the more important issues discovered. As a result, a review of this information as presented in the database was performed for all samples. There were 3 more samples that contained this inconsistency in the database. A review of the logbook notes is recommended in order to confirm the appropriate values for these fields. In addition, it was discovered in the verification process that the raw data for computing volume are not available in the database. Because only 4 air samples were verified during this effort, it was not inconvenient to verify this information manually based on the information contained in the FSDS forms. However, it is recommended that this information be collected electronically in future data collection efforts so that the raw data may be verified and also be available to data users that do not have the FSDS forms available to them.

ISSUE RESOLUTION AND STATUS

The issues discovered in the verification process are summarized in the comments above and in Table 1 provided below. In addition, Attachments 3a – 3c contain all samples that were verified and what information was verified. Attachment 3a contains the air FSDS verification, Attachment 3b contains the air pump information verification, and Attachment 3c contains the soil FSDS verification.

Table 1. Summary of Issues

Samp_No	Verification Notes
HW-00229	Sampling date is 7/28/10 on FSDS form.
HW-00129	Sample aliquots differ from number of vis verm observations.
HW-00130	Sample aliquots differ from number of vis verm observations.
HW-00133	Sample aliquots differ from number of vis verm observations.
HW-00082	Sample aliquots differ from number of vis verm observations.
HW-00087	FSDS has the location type as sampling location, not sampling point.
HW-00095	FSDS has the location type as sampling location, not sampling point.
HW-00639	Location description is null on FSDS form.
HW-00642	Location description is null on FSDS form.
HW-00644	Location description is null on FSDS form.
HW-00091	Sample composite in "N" on FSDS and "Y in database.
HW-00173	LocationID is "AD-OU8NA" in database and "NA" on FSDS form.
HW-00404	Sample Venue is not circled on FSDS form.

ATTACHMENT 1a. TEM VERIFICATION (Analytical and Results Information)

Samp_No	PersonnelTask	SampleQuantity	Analysis Quantity Analyzed	Analysis Date	AnalysisLabID	AnalysisAnalystName	AnalysisMethod	AnalysisLabJobNumber	AnalysisLabSampleID	AnalysisPrepMethod	AnalysisFilterStatus	Comments	AnalysisEFA	AnalysisGO Counted	AnalysisGO Chrys	AnalysisGO Size	AnalysisFFactor	ResultMineralClass	SENSITIVITY	STRUCTCNT	STRUCTCONC	Verifier's Initials	Verification Notes
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	CH	0.00200321	0	0	EK	
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	LA	0.00200321	0	0	EK	
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	OA	0.00200321	0	0	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	CH	0.00296628	0	0	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	LA	0.00296628	6	0.01779771	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	OA	0.00296628	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	CH	0.00296154	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	LA	0.00296154	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	OA	0.00296154	0	0	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	CH	0.0029969	0	0	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	LA	0.0029969	6	0.01798141	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	OA	0.0029969	0	0	EK	

ATTACHMENT 1b. TEM VERIFICATION (Raw Structure Information)

StructureID	Samp_No	AnalysisID	Grid	GridOpening	Structure Type	Mineral Class	Primary	Total	Length	Width	AR	StructureComment	Verifier's Initials	Verification Notes
271001351-0001_ISO_D-1	HW-00583	271001351-0001_ISO_D	A1	E2	ND								EK	
271001351-0001_ISO_D-2	HW-00583	271001351-0001_ISO_D	A1	E4	ND								EK	
271001351-0001_ISO_D-3	HW-00583	271001351-0001_ISO_D	A1	E6	ND								EK	
271001351-0001_ISO_D-4	HW-00583	271001351-0001_ISO_D	A1	E8	ND								EK	
271001351-0001_ISO_D-5	HW-00583	271001351-0001_ISO_D	A1	E10	ND								EK	
271001351-0001_ISO_D-6	HW-00583	271001351-0001_ISO_D	A1	F1	ND								EK	
271001351-0001_ISO_D-7	HW-00583	271001351-0001_ISO_D	A1	F3	ND								EK	
271001351-0001_ISO_D-8	HW-00583	271001351-0001_ISO_D	A1	F5	ND								EK	
271001351-0001_ISO_D-9	HW-00583	271001351-0001_ISO_D	A1	F7	ND								EK	
271001351-0001_ISO_D-10	HW-00583	271001351-0001_ISO_D	A1	F9	ND								EK	
271001351-0001_ISO_D-11	HW-00583	271001351-0001_ISO_D	A1	G2	ND								EK	
271001351-0001_ISO_D-12	HW-00583	271001351-0001_ISO_D	A1	G4	ND								EK	
271001351-0001_ISO_D-13	HW-00583	271001351-0001_ISO_D	A1	G6	ND								EK	
271001351-0001_ISO_D-14	HW-00583	271001351-0001_ISO_D	A1	G8	ND								EK	
271001351-0001_ISO_D-15	HW-00583	271001351-0001_ISO_D	A1	G10	ND								EK	
271001351-0001_ISO_D-16	HW-00583	271001351-0001_ISO_D	A1	H1	ND								EK	
271001351-0001_ISO_D-17	HW-00583	271001351-0001_ISO_D	A1	H3	ND								EK	
271001351-0001_ISO_D-18	HW-00583	271001351-0001_ISO_D	A1	H5	ND								EK	
271001351-0001_ISO_D-19	HW-00583	271001351-0001_ISO_D	A1	H7	ND								EK	
271001351-0001_ISO_D-20	HW-00583	271001351-0001_ISO_D	A1	H9	ND								EK	
271001351-0001_ISO_D-21	HW-00583	271001351-0001_ISO_D	A1	I2	ND								EK	
271001351-0001_ISO_D-22	HW-00583	271001351-0001_ISO_D	A1	I4	ND								EK	
271001351-0001_ISO_D-23	HW-00583	271001351-0001_ISO_D	A1	I6	ND								EK	
271001351-0001_ISO_D-24	HW-00583	271001351-0001_ISO_D	A1	I8	ND								EK	
271001351-0001_ISO_D-25	HW-00583	271001351-0001_ISO_D	A1	I10	ND								EK	
271001351-0001_ISO_D-26	HW-00583	271001351-0001_ISO_D	A2	B2	ND								EK	
271001351-0001_ISO_D-27	HW-00583	271001351-0001_ISO_D	A2	B4	ND								EK	
271001351-0001_ISO_D-28	HW-00583	271001351-0001_ISO_D	A2	B6	ND								EK	
271001351-0001_ISO_D-29	HW-00583	271001351-0001_ISO_D	A2	B8	ND								EK	
271001351-0001_ISO_D-30	HW-00583	271001351-0001_ISO_D	A2	B10	ND								EK	
271001351-0001_ISO_D-31	HW-00583	271001351-0001_ISO_D	A2	C1	ND								EK	
271001351-0001_ISO_D-32	HW-00583	271001351-0001_ISO_D	A2	C3	ND								EK	
271001351-0001_ISO_D-33	HW-00583	271001351-0001_ISO_D	A2	C5	ND								EK	
271001351-0001_ISO_D-34	HW-00583	271001351-0001_ISO_D	A2	C7	ND								EK	
271001351-0001_ISO_D-35	HW-00583	271001351-0001_ISO_D	A2	C9	ND								EK	
271001351-0001_ISO_D-36	HW-00583	271001351-0001_ISO_D	A2	D2	ND								EK	
271001351-0001_ISO_D-37	HW-00583	271001351-0001_ISO_D	A2	D4	ND								EK	
271001351-0001_ISO_D-38	HW-00583	271001351-0001_ISO_D	A2	D6	ND								EK	
271001351-0001_ISO_D-39	HW-00583	271001351-0001_ISO_D	A2	D8	ND								EK	
271001351-0001_ISO_D-40	HW-00583	271001351-0001_ISO_D	A2	D10	ND								EK	
271001351-0001_ISO_D-41	HW-00583	271001351-0001_ISO_D	A2	E1	ND								EK	
271001351-0001_ISO_D-42	HW-00583	271001351-0001_ISO_D	A2	E3	ND								EK	
271001351-0001_ISO_D-43	HW-00583	271001351-0001_ISO_D	A2	E5	ND								EK	
271001351-0001_ISO_D-44	HW-00583	271001351-0001_ISO_D	A2	E7	ND								EK	
271001351-0001_ISO_D-45	HW-00583	271001351-0001_ISO_D	A2	E9	ND								EK	
271001351-0001_ISO_D-46	HW-00583	271001351-0001_ISO_D	A2	F2	ND								EK	
271001351-0001_ISO_D-47	HW-00583	271001351-0001_ISO_D	A2	F4	ND								EK	
271001351-0001_ISO_D-48	HW-00583	271001351-0001_ISO_D	A2	F6	ND								EK	
271001351-0001_ISO_D-49	HW-00583	271001351-0001_ISO_D	A2	F8	ND								EK	
271001351-0001_ISO_D-50	HW-00583	271001351-0001_ISO_D	A2	F10	ND								EK	
271001351-0001_ISO_D-51	HW-00583	271001351-0001_ISO_D	A2	G1	ND								EK	
271001351-0001_ISO_D-52	HW-00583	271001351-0001_ISO_D	A2	G3	ND								EK	
271001351-0001_ISO_D-53	HW-00583	271001351-0001_ISO_D	A2	G5	ND								EK	
271001351-0001_ISO_D-54	HW-00583	271001351-0001_ISO_D	A2	G7	ND								EK	
271001351-0001_ISO_D-55	HW-00583	271001351-0001_ISO_D	A2	G9	ND								EK	
271001351-0001_ISO_D-56	HW-00583	271001351-0001_ISO_D	A3	F9	ND								EK	
271001351-0001_ISO_D-57	HW-00583	271001351-0001_ISO_D	A3	F7	ND								EK	
271001351-0001_ISO_D-58	HW-00583	271001351-0001_ISO_D	A3	F5	ND								EK	
271001351-0001_ISO_D-59	HW-00583	271001351-0001_ISO_D	A3	F3	ND								EK	
271001351-0001_ISO_D-60	HW-00583	271001351-0001_ISO_D	A3	F1	ND								EK	
271001351-0001_ISO_D-61	HW-00583	271001351-0001_ISO_D	A3	E10	ND								EK	
271001351-0001_ISO_D-62	HW-00583	271001351-0001_ISO_D	A3	E8	ND								EK	
271001351-0001_ISO_D-63	HW-00583	271001351-0001_ISO_D	A3	E6	ND								EK	
271001351-0001_ISO_D-64	HW-00583	271001351-0001_ISO_D	A3	E4	ND								EK	
271001351-0001_ISO_D-65	HW-00583	271001351-0001_ISO_D	A3	E2	ND								EK	
271001351-0001_ISO_D-66	HW-00583	271001351-0001_ISO_D	A3	D9	ND								EK	
271001351-0001_ISO_D-67	HW-00583	271001351-0001_ISO_D	A3	D7	ND								EK	
271001351-0001_ISO_D-68	HW-00583	271001351-0001_ISO_D	A3	D5	ND								EK	
271001351-0001_ISO_D-69	HW-00583	271001351-0001_ISO_D	A3	D3	ND								EK	
271001351-0001_ISO_D-70	HW-00583	271001351-0001_ISO_D	A3	D1	ND								EK	
271001351-0001_ISO_D-71	HW-00583	271001351-0001_ISO_D	A3	C10	ND								EK	
271001351-0001_ISO_D-72	HW-00583	271001351-0001_ISO_D	A3	C8	ND								EK	
271001351-0001_ISO_D-73	HW-00583	271001351-0001_ISO_D	A3	C6	ND								EK	
271001351-0001_ISO_D-74	HW-00583	271001351-0001_ISO_D	A3	C4	ND								EK	
271001351-0001_ISO_D-75	HW-00583	271001351-0001_ISO_D	A3	C2	ND								EK	
271001351-0001_ISO_D-76	HW-00583	271001351-0001_ISO_D	A3	B9	ND								EK	
271001351-0001_ISO_D-77	HW-00583	271001351-0001_ISO_D	A3	B7	ND								EK	
271001129-0004_ISO_D-1	HW-00594	271001129-0004_ISO_D	B5	H9	ND								EK	
271001129-0004_ISO_D-2	HW-00594	271001129-0004_ISO_D	B5	H7	ND								EK	
271001129-0004_ISO_D-3	HW-00594	271001129-0004_ISO_D	B5	H5	F	LA	1	1	40.1	3.25	12.3384615	NaK; WRTA;	EK	
271001129-0004_ISO_D-4	HW-00594	271001129-0004_ISO_D	B5	H3	ND								EK	
271001129-0004_ISO_D-5	HW-00594	271001129-0004_ISO_D	B5	H1	ND								EK	
271001129-0004_ISO_D-6	HW-00594	271001129-0004_ISO_D	B5	D9	F	LA	2	2	84.5	1	84.5	NaK; WRTA;	EK	
271001129-0004_ISO_D-7	HW-00594	271001129-0004_ISO_D	B5	D7	ND								EK	

ATTACHMENT 1b. TEM VERIFICATION (Raw Structure Information)

StructureID	Samp_No	AnalysisID	Grid	GridOpening	Structure Type	Mineral Class	Primary	Total	Length	Width	AR	StructureComment	Verifier's Initials	Verification Notes
271001129-0004_ISO_D-8	HW-00594	271001129-0004_ISO_D	B5	D5	ND								EK	
271001129-0004_ISO_D-9	HW-00594	271001129-0004_ISO_D	B5	D3	ND								EK	
271001129-0004_ISO_D-10	HW-00594	271001129-0004_ISO_D	B5	D1	ND								EK	
271001129-0004_ISO_D-11	HW-00594	271001129-0004_ISO_D	B5	C8	ND								EK	
271001129-0004_ISO_D-12	HW-00594	271001129-0004_ISO_D	B5	C6	ND								EK	
271001129-0004_ISO_D-13	HW-00594	271001129-0004_ISO_D	B5	C4	F	LA	3	3	12.4	0.4	31	NaK; WRTA;	EK	
271001129-0004_ISO_D-14	HW-00594	271001129-0004_ISO_D	B6	G5	ND								EK	
271001129-0004_ISO_D-15	HW-00594	271001129-0004_ISO_D	B6	G3	ND								EK	
271001129-0004_ISO_D-16	HW-00594	271001129-0004_ISO_D	B6	G1	ND								EK	
271001129-0004_ISO_D-17	HW-00594	271001129-0004_ISO_D	B6	E9	ND								EK	
271001129-0004_ISO_D-18	HW-00594	271001129-0004_ISO_D	B6	E7	ND								EK	
271001129-0004_ISO_D-19	HW-00594	271001129-0004_ISO_D	B6	E5	F	LA	4	4	13.5	1	13.5	NaK; WRTA;	EK	
271001129-0004_ISO_D-20	HW-00594	271001129-0004_ISO_D	B6	E3	ND								EK	
271001129-0004_ISO_D-21	HW-00594	271001129-0004_ISO_D	B6	E1	ND								EK	
271001129-0004_ISO_D-22	HW-00594	271001129-0004_ISO_D	B6	C9	ND								EK	
271001129-0004_ISO_D-23	HW-00594	271001129-0004_ISO_D	B6	C7	ND								EK	
271001129-0004_ISO_D-24	HW-00594	271001129-0004_ISO_D	B6	C5	ND								EK	
271001129-0004_ISO_D-25	HW-00594	271001129-0004_ISO_D	B6	C3	F	LA	5	5	23.75	0.7	33.9285714	NaK; WRTA;	EK	
271001129-0004_ISO_D-26	HW-00594	271001129-0004_ISO_D	B6	C1	MD11		6						EK	
271001129-0004_ISO_D-27	HW-00594	271001129-0004_ISO_D	B6	C1	MF	LA		6	7	1.1	6.36363636	NaK; WRTA;	EK	
271001354-0004_ISO_D-1	HW-00606	271001354-0004_ISO_D	L4	F2	ND								EK	
271001354-0004_ISO_D-2	HW-00606	271001354-0004_ISO_D	L4	F4	ND								EK	
271001354-0004_ISO_D-3	HW-00606	271001354-0004_ISO_D	L4	F6	ND								EK	
271001354-0004_ISO_D-4	HW-00606	271001354-0004_ISO_D	L4	F8	ND								EK	
271001354-0004_ISO_D-5	HW-00606	271001354-0004_ISO_D	L4	F10	ND								EK	
271001354-0004_ISO_D-6	HW-00606	271001354-0004_ISO_D	L4	G1	ND								EK	
271001354-0004_ISO_D-7	HW-00606	271001354-0004_ISO_D	L4	G3	ND								EK	
271001354-0004_ISO_D-8	HW-00606	271001354-0004_ISO_D	L4	G5	ND								EK	
271001354-0004_ISO_D-9	HW-00606	271001354-0004_ISO_D	L4	G7	ND								EK	
271001354-0004_ISO_D-10	HW-00606	271001354-0004_ISO_D	L4	G9	ND								EK	
271001354-0004_ISO_D-11	HW-00606	271001354-0004_ISO_D	L4	H6	ND								EK	
271001354-0004_ISO_D-12	HW-00606	271001354-0004_ISO_D	L4	H8	ND								EK	
271001354-0004_ISO_D-13	HW-00606	271001354-0004_ISO_D	L4	H10	ND								EK	
271001354-0004_ISO_D-14	HW-00606	271001354-0004_ISO_D	L5	E9	ND								EK	
271001354-0004_ISO_D-15	HW-00606	271001354-0004_ISO_D	L5	E7	ND								EK	
271001354-0004_ISO_D-16	HW-00606	271001354-0004_ISO_D	L5	E5	ND								EK	
271001354-0004_ISO_D-17	HW-00606	271001354-0004_ISO_D	L5	E3	ND								EK	
271001354-0004_ISO_D-18	HW-00606	271001354-0004_ISO_D	L5	E1	ND								EK	
271001354-0004_ISO_D-19	HW-00606	271001354-0004_ISO_D	L5	D10	ND								EK	
271001354-0004_ISO_D-20	HW-00606	271001354-0004_ISO_D	L5	D8	ND								EK	
271001354-0004_ISO_D-21	HW-00606	271001354-0004_ISO_D	L5	D6	ND								EK	
271001354-0004_ISO_D-22	HW-00606	271001354-0004_ISO_D	L5	D4	ND								EK	
271001354-0004_ISO_D-23	HW-00606	271001354-0004_ISO_D	L5	D2	ND								EK	
271001354-0004_ISO_D-24	HW-00606	271001354-0004_ISO_D	L5	C3	ND								EK	
271001354-0004_ISO_D-25	HW-00606	271001354-0004_ISO_D	L5	C1	ND								EK	
271001352-0004_ISO_D-1	HW-00626	271001352-0004_ISO_D	J4	D9	ND								EK	
271001352-0004_ISO_D-2	HW-00626	271001352-0004_ISO_D	J4	D7	ND								EK	
271001352-0004_ISO_D-3	HW-00626	271001352-0004_ISO_D	J4	D5	F	LA	1	1	11.5	0.7	16.4285714	WRTA/NaK; F	EK	
271001352-0004_ISO_D-4	HW-00626	271001352-0004_ISO_D	J4	D3	MD10		2						EK	
271001352-0004_ISO_D-5	HW-00626	271001352-0004_ISO_D	J4	D3	MF	LA		2	4.75	0.25	19	WRTA/NaK; F	EK	
271001352-0004_ISO_D-6	HW-00626	271001352-0004_ISO_D	J4	D1	ND								EK	
271001352-0004_ISO_D-7	HW-00626	271001352-0004_ISO_D	J4	C10	ND								EK	
271001352-0004_ISO_D-8	HW-00626	271001352-0004_ISO_D	J4	C8	ND								EK	
271001352-0004_ISO_D-9	HW-00626	271001352-0004_ISO_D	J4	C6	ND								EK	
271001352-0004_ISO_D-10	HW-00626	271001352-0004_ISO_D	J4	C4	ND								EK	
271001352-0004_ISO_D-11	HW-00626	271001352-0004_ISO_D	J4	C2	ND								EK	
271001352-0004_ISO_D-12	HW-00626	271001352-0004_ISO_D	J4	B9	ND								EK	
271001352-0004_ISO_D-13	HW-00626	271001352-0004_ISO_D	J4	B7	ND								EK	
271001352-0004_ISO_D-14	HW-00626	271001352-0004_ISO_D	J4	B5	ND								EK	
271001352-0004_ISO_D-15	HW-00626	271001352-0004_ISO_D	J4	B3	F	LA	3	3	10	1.7	5.88235294	WRTA/NaK; F	EK	
271001352-0004_ISO_D-16	HW-00626	271001352-0004_ISO_D	J4	B1	ND								EK	
271001352-0004_ISO_D-17	HW-00626	271001352-0004_ISO_D	J5	E10	F	LA	4	4	7	0.25	28	WRTA/Nak; F	EK	
271001352-0004_ISO_D-18	HW-00626	271001352-0004_ISO_D	J5	E8	ND								EK	
271001352-0004_ISO_D-19	HW-00626	271001352-0004_ISO_D	J5	E6	ND								EK	
271001352-0004_ISO_D-20	HW-00626	271001352-0004_ISO_D	J5	E4	ND								EK	
271001352-0004_ISO_D-21	HW-00626	271001352-0004_ISO_D	J5	E2	ND								EK	
271001352-0004_ISO_D-22	HW-00626	271001352-0004_ISO_D	J5	D9	F	LA	5	5	6	0.2	30	WRTA/NaK; F	EK	
271001352-0004_ISO_D-23	HW-00626	271001352-0004_ISO_D	J5	D7	F	LA	6	6	7.75	0.4	19.375	WRTA/NaK	EK	
271001352-0004_ISO_D-24	HW-00626	271001352-0004_ISO_D	J5	D5	ND								EK	
271001352-0004_ISO_D-25	HW-00626	271001352-0004_ISO_D	J5	D3	ND								EK	
271001352-0004_ISO_D-26	HW-00626	271001352-0004_ISO_D	J5	D1	ND								EK	
271001352-0004_ISO_D-27	HW-00626	271001352-0004_ISO_D	J5	C4	ND								EK	
271001352-0004_ISO_D-28	HW-00626	271001352-0004_ISO_D	J5	C2	ND								EK	

ATTACHMENT 2. PLM-VE VERIFICATION

										Opitcal Property Data for Detected Samples									
SampleNo	Tag	Lab Job Number	AnalysisLabSampleID	Date Analyzed	AnalysisLabSampleID	AnalysisAppearance	LA	OA	C	FBRCOLOR	ELONG	PLEOCH	EXTINCT	RIALPHA	RIGAMMA	BIREF	HABIT	Verifier's Initials	Verification Notes
HW-00009	FG1	A101371	A101371-9	12/9/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00021	FG1	A101381	A101381-1	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00023	FG1	A101381	A101381-3	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00026	FG1	A101381	A101381-6	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00029	FG1	A101381	A101381-9	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00039	FG1	A101381	A101381-19	12/14/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.618	1.64	Medium	Prismatic	EK	
HW-00046	FG1	A101379	A101379-6	12/13/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00055	FG1	A101379	A101379-15	12/14/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00057	FG1	A101379	A101379-17	12/15/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00070	FG1	A101372	A101372-10	12/9/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00075	FG1	A101372	A101372-15	12/9/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00076	FG1	A101372	A101372-16	12/10/10	A. Goncalves	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.619	1.627	Low	Prismatic	EK	
HW-00080	FG1	A101372	A101372-20	12/10/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00083	FG1	A101373	A101373-3	12/9/10	N. Fischer	Brown soil, fine	Tr	ND	ND	Tan	Positive	No	Inclined	1.619	1.636	Medium	FIBER BUNDLE	EK	
HW-00087	FG1	A101373	A101373-7	12/9/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	analyst's initials unclear
HW-00091	FG1	A101373	A101373-11	12/9/10	N. MacDonald	Tan soil, fine	ND	ND	ND									EK	
HW-00094	FG1	A101373	A101373-14	12/9/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00095	FG1	A101373	A101373-15	12/9/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00104	FG1	A101382	A101382-4	12/13/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00121	FG1	A101383	A101383-1	12/14/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00129	FG1	A101383	A101383-9	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00132	FG1	A101383	A101383-12	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00137	FG1	A101383	A101383-17	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00150	FG1	A101384	A101384-10	12/15/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00151	FG1	A101384	A101384-11	12/15/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00161	FG1	A101385	A101385-1	12/18/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00168	FG1	A101385	A101385-8	12/18/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00173	FG1	A101385	A101385-13	12/20/10	T. Oliver	Tan soil, fine	ND	ND	ND									EK	
HW-00179	FG1	A101385	A101385-19	12/20/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00184	FG1	A101386	A101386-4	12/21/10	N. MacDonald	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.625	1.641	Medium	FIBER BUNDLE	EK	
HW-00195	FG1	A101386	A101386-15	12/21/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00200	FG1	A101386	A101386-20	12/21/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00206	FG1	A101387	A101387-6	12/17/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00208	FG1	A101387	A101387-8	12/17/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00216	FG1	A101387	A101387-16	12/20/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00218	FG1	A101387	A101387-18	12/20/10	A. Goncalves	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.635	1.641	Low	FIBER BUNDLE	EK	
HW-00229	FG1	A101388	A101388-9	12/17/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00231	FG1	A101388	A101388-11	12/17/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00240	FG1	A101388	A101388-20	12/20/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00243	FG1	A101389	A101389-3	12/21/10	T. Oliver	Brown soil, fine	Tr	ND	ND	GRAY	Positive	No	Inclined	1.617	1.638	Medium	FIBER BUNDLE	EK	
HW-00249	FG1	A101389	A101389-9	12/21/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00260	FG1	A101389	A101389-20	12/22/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00266	FG1	A101390	A101390-6	12/21/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00271	FG1	A101390	A101390-11	12/21/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00272	FG1	A101390	A101390-12	12/22/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00273	FG1	A101390	A101390-13	12/22/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00294	FG1	A101391	A101391-14	12/23/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00304	FG1	A101392	A101392-4	12/29/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00312	FG1	A101392	A101392-12	12/29/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00315	FG1	A101392	A101392-15	12/29/10	N. MacDonald	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.619	1.638	Medium	FIBER BUNDLE	EK	
HW-00347	FG1	A101394	A101394-7	12/29/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00358	FG1	A101394	A101394-18	12/30/10	N. Fischer	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.619	1.635	Medium	Prismatic	EK	
HW-00382	FG1	A101396	A101396-2	12/30/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.617	1.637	Medium	Prismatic	EK	
HW-00393	FG1	A101396	A101396-13	1/3/11	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00404	FG1	A101397	A101397-4	1/4/11	N. MacDonald	Tan soil, fine	ND	ND	ND									EK	
HW-00639	FG1	A101254	A101254-3	10/25/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00642	FG1	A101254	A101254-6	10/25/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.638	1.643	Low	FIBER BUNDLE	EK	
HW-00644	FG1	A101254	A101254-8	10/25/10	T. Oliver	Brown soil, fine	Tr	ND	ND	GRAY	Positive	No	Inclined	1.642	1.65	Low	FIBER BUNDLE	EK	

ATTACHMENT 3a. AIR FSDS VERIFICATION

Samp_No	Sample Venue	Sample Air Type	Personnel Task	SampleDate	Location	Sub_Location	Location Description	Sample Type	Sample Quantity	Sample Quantity Units	Sample Field Comments	Verifier's Initials	Verification Notes
HW-00583	Outdoor	PA-ABS	Brush hogging	07-Sep-10	XX-002392	Tractor Back ; Hi; MM2 to First driveway; Hwy 37 N	Right of Way - only	Field Sample	192	L		EK	Verifier manually checked volume; info not available in DB.
HW-00594	Outdoor	PA-ABS	Brush hogging	07-Sep-10	XX-002394	Tractor Back; Hi; Driveway across from Amerigas; Hwy 37 N	Right of Way - only	Field Sample	384	L		EK	Verifier manually checked volume; info not available in DB.
HW-00606	Outdoor	PA-ABS	ATV riding	08-Sep-10	XX-002397	Hwy 37 mm 4.4 to 5.5 West Side Only Off Road Follow Hi	Right of Way - only	Field Sample	400	L	Pump 10 for 28 mins then pump 2 for 12 mins	EK	Verifier manually checked volume; info not available in DB.
HW-00626	Outdoor	PA-ABS	Brush hogging	09-Sep-10	XX-002401	MM 4.5 to 4.0 Hwy 37 W Tractor Front Hi	Right of Way - only	Field Sample	366	L		EK	Verifier manually checked volume; info not available in DB.

ATTACHMENT 3b. AIR FSDS VERIFICATION (PUMP INFORMATION)

Panel A: Pump Information Data Entry

Samp_No	Start Flow	End Flow	Start_DateTime	Stop_DateTime	Vol Interval
HW-00583	3	3	9/7/10 9:40	9/7/10 10:44	192
HW-00594	3	3	9/7/10 10:53	9/7/10 12:00	201
HW-00594	3	3	9/7/10 12:23	9/7/10 13:24	183
HW-00606	10	10	9/8/10 8:59	9/8/10 9:27	280
HW-00606	10	10	9/8/10 10:37	9/8/10 10:49	120
HW-00626	3	3	9/9/10 9:00	9/9/10 11:02	366

Panel B: Volume Calculation

Samp_No	Volume	Verifier's Initials	Verification Notes
HW-00583	192	EK	
HW-00594	384	EK	
HW-00606	400	EK	
HW-00626	366	EK	

ATTACHMENT 3c. SOIL FSDS VERIFICATION

Samp_No	SampleDate	Sample Venue	LocationType	Location	Sub_Location	LocationDescription	Visible Vermiculite None	Low	Medium	High	Comments	SampleType	SampleCompositeYN	SampleAliquots	Samp_Depth	Samp_Depth_To	SampleField Comments	Verifier's Initials	Verification Notes
HW-00168	7/26/10	Outdoor	Sampling Point	XX-002072	South Shoulder East of Easy St	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00179	7/26/10	Outdoor	Sampling Point	XX-002081	South Shoulder at Quartz Creek Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00184	7/26/10	Outdoor	Sampling Point	XX-002086	South Shoulder near 2455 K. River Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00195	7/27/10	Outdoor	Sampling Point	XX-002095	North Shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00200	7/27/10	Outdoor	Sampling Point	XX-002100	North shoulder West of mile 1 marker	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00206	7/27/10	Outdoor	Sampling Point	XX-002106	North shoulder West of mile 2 marker	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00208	7/27/10	Outdoor	Sampling Point	XX-002108	North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00216	7/27/10	Outdoor	Sampling Point	XX-002114	North Shoulder 3803 Kootenai River Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00218	7/27/10	Outdoor	Sampling Point	XX-002116	North Shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00229	7/29/10	Outdoor	Sampling Point	XX-002127	North Shoulder by Cliffside Drive	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	Sampling date is 7/28/10 on FSDS form
HW-00231	7/28/10	Outdoor	Sampling Point	XX-002129	North Shoulder approaching end	Right of Way - only	8	0	0	0		Field Sample	Yes	8	0	3		EK	
HW-00104	7/23/10	Outdoor	Sampling Point	XX-002014	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00121	7/24/10	Outdoor	Sampling Point	XX-002029	Pipe Creek Rd (West Shoulder) South of Sanitary Lan	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00129	7/24/10	Outdoor	Sampling Point	XX-002036	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	6	0	3	No Grass	EK	Sample aliquots differ from number of vis verm observations.
HW-00130	7/24/10	Outdoor	Sampling Point	XX-002037	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	7	0	3	no grass		Sample aliquots differ from number of vis verm observations.
HW-00132	7/24/10	Outdoor	Sampling Point	XX-002038	Pipe Creek Rd (West Shoulder) South of Power Statio	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00133	7/24/10	Outdoor	Sampling Point	XX-002039	Pipe Creek Rd (West Shoulder) North of 37	Right of Way - only	10	0	0	0	cut of grass	Field Sample	Yes	6	0	3	Out of Grass		Sample aliquots differ from number of vis verm observations.
HW-00137	7/24/10	Outdoor	Sampling Point	XX-002043	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00150	7/25/10	Outdoor	Sampling Point	XX-002056	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00151	7/25/10	Outdoor	Sampling Point	XX-002056	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Duplicat	Yes	10	0	3		EK	
HW-00161	7/25/10	Outdoor	Sampling Point	XX-002065	Pipe Creek Rd East Shoulder (Mile Marker 5) North of	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00312	7/30/10	Outdoor	Sampling Point	XX-002202	Begin N of Concrete Barriers	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00315	7/30/10	Outdoor	Sampling Point	XX-002205	N Bound 2 near Cedar Creek	Right of Way - only	7	0	0	0		Field Sample	Yes	7	0	3	Guard Rail	EK	
HW-00347	7/31/10	Outdoor	Sampling Point	XX-002233	South bound side	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00358	8/1/10	Outdoor	Sampling Point	XX-002244	Kootenai River Outfitters	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00382	8/2/10	Outdoor	Sampling Point	XX-002265	Coles Rd	Right of Way - only	10	0	0	0		Field Duplicat	Yes	10	0	3		EK	
HW-00393	8/3/10	Outdoor	Sampling Point	XX-002275	Begin N end of rail	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00240	7/28/10	Outdoor	Sampling Point	XX-002136	SE Bound Farm to Market near McKays St	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00243	7/28/10	Outdoor	Sampling Point	XX-002139	NW Bound Granny's Garden Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00249	7/28/10	Outdoor	Sampling Point	XX-002145	NW bound 1657 Farm to Market	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00260	7/29/10	Outdoor	Sampling Point	XX-002154	SE Bound Begin NW of Evans Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00266	7/29/10	Outdoor	Sampling Point	XX-002160	SE Bound by Mine by Mile 3	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00271	7/29/10	Outdoor	Sampling Point	XX-002165	NW Bound Across from Mine	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00272	7/29/10	Outdoor	Sampling Point	XX-002166	SE Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00273	7/29/10	Outdoor	Sampling Point	XX-002167	SE Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00294	7/29/10	Outdoor	Sampling Point	XX-002186	SE Bound NW Corner of Meadowlark	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00304	7/30/10	Outdoor	Sampling Point	XX-002194	NW Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00009	7/20/10	Outdoor	Sampling Point	XX-001929	Hwy 37 East of (south Shoulder) mile marker 7	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00021	7/21/10	Outdoor	Sampling Point	XX-001939	Hwy 37 (south Shoulder) West of mile marker 11	Right of Way - only	6	4	0	0	Small amou	Field Sample	Yes	10	0	3		EK	
HW-00023	7/21/10	Outdoor	Sampling Point	XX-001941	Hwy 37 (South Shoulder) West of 11501 Hwy 37	Right of Way - only	8	2	0	0	Small amou	Field Sample	Yes	10	0	3		EK	
HW-00026	7/21/10	Outdoor	Sampling Point	XX-001944	Hwy 37 (South shoulder) West of Mile marker 12	Right of Way - only	5	5	0	0	Small amou	Field Sample	Yes	10	0	3		EK	
HW-00029	7/21/10	Outdoor	Sampling Point	XX-001947	Hwy 37 (South Shoulder) (Mile Marker 13)	Right of Way - only	7	3	0	0	small amou	Field Sample	Yes	10	0	3		EK	
HW-00039	7/21/10	Outdoor	Sampling Point	XX-001956	Hwy 37 (South Shoulder)	Right of Way - only	5	5	0	0	Small amou	Field Sample	Yes	10	0	3		EK	
HW-00046	7/21/10	Outdoor	Sampling Point	XX-001962	Hwy 37 (South shoulder) West of mile post 17	Right of Way - only	9	1	0	0	Small amou	Field Sample	Yes	10	0	3		EK	
HW-00055	7/22/10	Outdoor	Sampling Point	XX-001969	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00057	7/22/10	Outdoor	Sampling Point	XX-001971	Highway 37 North shoulder East of River Bend	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00070	7/22/10	Outdoor	Sampling Point	XX-001983	Highway 37 north shoulder west of mile post 11	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00075	7/22/10	Outdoor	Sampling Point	XX-001987	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00076	7/23/10	Outdoor	Sampling Point	XX-001988	Highway 37 North shoulder West of 10000 Highway 3	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00080	7/23/10	Outdoor	Sampling Point	XX-001991	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00082	7/23/10	Outdoor	Sampling Point	XX-001993	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	7	0	3			Sample aliquots differ from number of vis verm observations.
HW-00083	7/23/10	Outdoor	Sampling Point	XX-001994	Highway 37 North shoulder East of National Forest Bo	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00087	7/23/10	Outdoor	Sampling Point	XX-001998	Highway 37 North shoulder mile marker 8	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	FSDS has the location type as sampling location, not sampling point.
HW-00094	7/23/10	Outdoor	Sampling Point	XX-002004	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00095	7/23/10	Outdoor	Sampling Point	XX-002005	Highway 37 North shoulder; 6884-6814 Highway 37	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	FSDS has the location type as sampling location, not sampling point.
HW-00639	9/9/10	Outdoor	Sampling Point	XX-002392	HWY 37 E SHOULDER MM 2 TO DRIVEWAY WITH F	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3	NO FIELD BL	EK	Location description is null on FSDS form
HW-00642	9/9/10	Outdoor	Sampling Point	XX-002395	HWY 37 E SHOULDER MM 3.0 TO ~MM 3.5	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3	NO FIELD BL	EK	Location description is null on FSDS form
HW-00644	9/9/10	Outdoor	Sampling Point	XX-002397	HWY 37 W SHOULDER MM 4.4 TO RAINEY CREEK	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3		EK	Location description is null on FSDS form
HW-00091	7/23/10	NA	NA	AD-OU8NA	Field Blank (Sand)	NA						Field Blank	Yes	0	0	0		EK	Sample composite in "N" on FSDS and "Y in database.
HW-00173	7/26/10	NA	NA	AD-OU8NA	Field Blank	NA						Field Blank	No	0	0	0		EK	LocationID is "AD-OU8NA" in database and "NA" on FSDS form.
HW-00404	8/3/10	NA	NA	AD-OU8NA	Field Blank-Sand	NA						Field Blank	No	0	0	0		EK	Sample Venue is not circled on FSDS form.

Appendix B
EPA Scribe Database

(A copy of the Database may be requested by contacting the Region 8 EPA Records Center)

Appendix C
Asbestos Analysis Methods and Data Reduction Techniques

ASBESTOS ANALYSIS METHODS AND DATA REDUCTION TECHNIQUES

1 Asbestos Mineralogy

Asbestos is the generic name for the fibrous habit of a broad family of naturally occurring poly-silicate minerals. Based on crystal structure, asbestos minerals are usually divided into two groups: serpentine and amphibole.

- *Serpentine*: The only asbestos mineral in the serpentine group is chrysotile. Chrysotile is the most widely used form of asbestos, accounting for about 90% of the asbestos used in commercial products (IARC 1977). There is no evidence that chrysotile occurs in the Libby vermiculite deposit, although it may be present in some types of building materials in Libby.

- *Amphiboles*: Five minerals in the amphibole group that occur in the asbestiform habit have found limited use in commercial products (IARC 1977), including:

  - actinolite
  - amosite
  - anthophyllite
  - crocidolite
  - tremolite

At the Libby site, the form of asbestos that is present in the vermiculite deposit is an amphibole asbestos that for many years was classified as tremolite/actinolite (e.g., McDonald et al 1986a, Amandus and Wheeler 1987). More recently, the U.S. Geological Service (USGS) performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from asbestos veins at the mine (Meeker et al. 2003). Using mineralogical naming rules recommended by Leake et al. (1997), the results indicate that the asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, actinolite, and magnesioriebeckite. Because the mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because EPA does not find that there are toxicological data to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as Libby Amphibole (LA) asbestos.

2 Measurement Techniques for Asbestos in Air

In the past, the most common technique for measuring asbestos in air was phase contrast microscopy (PCM). In this technique, air is drawn through a filter and airborne particles become deposited on the face of the filter. All structures that have a length greater than 5 um and have an aspect ratio (the ratio of length to width) of 3:1 or more are counted as PCM fibers. The limit of resolution of PCM is about 0.25 um, so particles thinner than this are generally not observable.

A key limitation of PCM is that particle discrimination is based only on size and shape. Because of this, it is not possible to classify asbestos particles by mineral type, or even to distinguish between asbestos and non-asbestos particles. For this reason, nearly all samples of air collected in Libby are analyzed by transmission electron microscopy (TEM). This method operates at higher magnification (typically about 20,000x) and hence is able to detect structures much smaller than can been seen by PCM. In addition, TEM instruments are fitted with accessories that allow each particle to be classified according to mineral type.

3 Transmission Electron Microscopy (TEM)

3.1 Sample Preparation

If air samples were not deemed to be overloaded by particulates[1], filters are directly prepared for analysis by transmission electron microscopy (TEM) in accord with the preparation methods provided in ISO 10312 (ISO 1995).

If air samples are deemed to be overloaded, samples are prepared indirectly (either with or without ashing as determined by the analyst) in accord with the procedures in SOP EPA-LIBBY-08. In brief, rinsate or ashed residue from the original filter is suspended in water and sonicated. An aliquot of this water is applied to a second filter which is then used to prepare a set of TEM grids. Reported air concentrations for indirectly prepared samples incorporate a dilution factor, or F-factor (see Section 3.4 below).

3.2 Sample Analysis

Air samples collected as part of the OU8 sampling programs were analyzed by TEM in basic accord with the counting and recording rules specified in ISO 10312 (ISO 1995), and certain project-specific counting rule modifications. These modifications included changing the recording rule to include structures with an aspect ratio ≥ 3:1.

When a sample is analyzed by TEM, the analyst records the size (length, width) and mineral type of each individual asbestos structure that is observed. Mineral type is determined by Selected Area Electron Diffraction (SAED) and Energy Dispersive Spectroscopy (EDS), and each structure is assigned to one of the following four categories:

LA *Libby-class amphibole.* Structures having an amphibole SAED pattern and an elemental composition similar to the range of fiber types observed in ores from

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[1] Overloaded is defined as >25% obscuration on the majority of the grid openings (see Libby Laboratory Modification #LB-000016 and SOP EPA-LIBBY-08).

the Libby mine (Meeker et al. 2003). This is a sodic tremolitic solid solution series of minerals including actinolite, tremolite, winchite, and richterite, with lower amounts of magnesio-arfedsonite and edenite/ferro-edenite.

OA *Other amphibole-type asbestos fibers.* Structures having an amphibole SAED pattern and an elemental composition that is not similar to fiber types from the Libby mine. Examples include crocidolite, amosite, and anthophyllite. There is presently no evidence that these fibers are associated with the Libby mine.

C *Chrysotile fibers.* Structures having a serpentine SAED pattern and an elemental composition characteristic of chrysotile. There is presently no evidence that these fibers are associated with the Libby mine.

NAM *Non-asbestos material.* These may include non-asbestos mineral fibers such as gypsum, glass, or clay, and may also include various types of organic and synthetic fibers derived from carpets, hair, etc.

For the purposes of this report, air concentrations are based on countable LA structures only (i.e., results for other amphibole-type asbestos and chrysotile are not discussed).

3.3 Estimation of PCME

For the purposes of computing risk estimates, it is necessary to utilize the results from a TEM analysis to estimate what would have been detected had the sample been analyzed by PCM. This is because available toxicity information is usually based on workplace studies that utilized PCM as the primary method for analysis. For convenience, structures detected under TEM that meet the recording rules for PCM (i.e., length > 5 um, width ≥ 0.25 um, aspect ratio ≥ 3:1) are referred to as PCM-equivalent (PCME) structures.

There are two alternative approaches available for expressing units of PCME s/cc. The first (and most direct) approach is to express the concentration of each sample in terms of the PCME structures observed in that sample. The second approach is to express the concentration of LA in each sample in terms of the total LA in that sample, and then multiply the total LA concentration by a value that represents the average fraction of total LA structures that meet PCME counting rules. For this evaluation, the first approach was followed.

In this document, all air concentrations will be reported in units of PCME LA s/cc.

3.4 *Calculation of Air Concentrations*

The concentration of LA in air is given by:

$$\text{Air Concentration (s/cc)} = N \cdot S$$

where:

N = Number of structures observed
S = Sensitivity (cc^{-1})

For air, the sensitivity is calculated as:

$$S = \frac{EFA}{GO \cdot Ago \cdot V \cdot 1000 \cdot F}$$

where:

S	=	Sensitivity for air (cc^{-1})
EFA	=	Effective area of the filter (mm^2)
GO	=	Number of grid openings examined
Ago	=	Area of a grid opening (mm^2)
V	=	Volume of air passed through the filter (L)
1000	=	Conversion factor (cc/L)
F	=	Fraction of primary filter deposited on secondary filter (indirect preparation only)

3.5 *Estimating Confidence Bounds*

For an Individual Sample

The uncertainty around a TEM estimate of asbestos concentration in a sample is a function of the number of structures observed during the analysis.

The 95% confidence interval around a count of N structures is given by:

LB = ½·CHIINV[0.025, 2N+1]
UB = ½·CHIINV[0.975, 2N+1]

where:

LB = Lower bound on the 95% confidence interval on N
UB = Upper bound on the 95% confidence interval on N
CHIINV = Inverse chi-squared cumulative distribution function
N = Number of structures observed

As N increases, the absolute width of the confidence interval increases, but the relative uncertainty [expressed as the confidence interval (CI) divided by the observed value (N)] decreases. This is illustrated in the table below.

Relationship Between Number of Structures Observed and Relative Uncertainty

Number of Structures Observed (N)	2.5% Lower Bound N (LB)	97.5% Upper Bound N (UB)	95% Confidence Interval Range (CI) [UB-LB]	Relative Uncertainty [CI/N]
0	0.00	2.51	2.51	+Infinity
1	0.11	4.67	4.57	457%
2	0.42	6.42	6.00	300%
3	0.84	8.01	7.16	239%
5	1.91	10.96	9.05	181%
10	5.14	17.74	12.60	126%
20	12.61	30.28	17.67	88%
50	37.54	65.35	27.81	56%
75	59.44	93.46	34.02	45%
100	81.82	121.08	39.26	39%

2.5% LB = 0.5 · CHIINV[0.975, (2 · N+1)]
97.5% UB = 0.5 · CHIINV[0.025, (2 · N+1)]

Using this approach, the equation for calculation of the upper and lower bounds on the air concentration of asbestos structures is:

Air Concentration (s/cc) = (LB or UB) · S

where:

LB or UB = Number of structures based on lower bound (LB) or upper bound (UB)
S = Sensitivity (cc^{-1} for air)

Across Multiple Samples

Calculation of the uncertainty bounds around the average of a group of asbestos samples is complicated by the fact that the between-sample variability in the measured concentration values includes the between-sample variability that arises from both analytical measurement error in individual samples and from between-sample temporal or spatial variability. EPA has not yet developed a method for calculating uncertainty bounds around the mean of asbestos data sets, so no uncertainty bounds are provided in this report for mean values (EPA, 2008[2]). However, it is important to recognize that the values are uncertain, and that actual values might be either higher or lower than reported.

4 Polarized Light Microscopy Analysis (PLM)

4.1 Sample Preparation

Soil samples collected as part of the OU8 sampling programs were prepared for analysis in accord with SOP ISSI-LIBBY-01 as specified in the CDM Close Support Facility (CSF) Soil Preparation Plan (SPP) (CDM, 2004). In brief, each soil sample is dried and sieved through a ¼ inch screen. Particles retained on the screen (if any) are referred to as the "coarse" fraction. Particles passing through the screen are referred to as the fine fraction, and this fraction is ground by passing it through a plate grinder. The resulting material is referred to as the "fine ground" fraction. The fine ground fraction is split into four equal aliquots; one aliquot is submitted for analysis and the remaining aliquots are archived at the CSF.

4.2 Sample Analysis

Soil samples collected at the Libby Site are analyzed using polarized light microscopy (PLM). The coarse fractions were examined using stereomicroscopy, and any particles of asbestos (confirmed by PLM) were removed and weighed in accord with SRC-LIBBY-01 (referred to as

[2] EPA. 2008. Framework for Investigating Asbestos-Contaminated Sites. Report prepared by the Asbestos Committee of the Technical Review Workgroup of the Office of Solid Waste and Emergency Response, U.S. Environmental protection Agency. OSWER Directive #9200.0-68.

"PLM-Grav"). Of the 508 soil field samples collected during these OU8 sampling program, only 4 samples had a coarse fraction.

The fine ground aliquots were analyzed using a Libby-specific PLM method using visual area estimation, as detailed in SOP SRC-LIBBY-03. For convenience, this method is referred to as "PLM-VE".

PLM-VE is a semi-quantitative method that utilizes site-specific LA reference materials to allow assignment of fine ground samples into one of four "bins", as follows:

- *Bin A (ND):* non-detect
- *Bin B1 (Trace):* detected at levels lower than the 0.2% LA reference material
- *Bin B2 (<1%):* detected at levels lower than the 1% LA reference material but higher than the 0.2% LA reference material
- *Bin C:* LA detected at levels greater than or equal to the 1% LA reference material

5 Soil Visual Inspection

At the time of soil sample collection for PLM analysis, the sampling team performed a visual inspection of the displaced soil at each sampling point to determine if visible vermiculite was present in accord with SOP CDM-LIBBY-06. A semi-quantitative estimate (none, low, medium[3], high) of the amount of visible vermiculite present was noted for each sampling point. For composite samples, a count of the number of sampling points assigned to each visible vermiculite ranking was recorded on the Field Sample Data Sheet (FSDS) in the sample comments (e.g., 18 none [X], 6 low [L], 4 medium [M], 2 high [H]).

There are several alternative ways that this visual inspection data can be used to characterize the level of vermiculite contamination (and presumptive LA contamination) in an area.

<u>Option 1: Present/Absent</u>

The simplest strategy classifies an area either as "Vis –" if all sampling points in the composite were assigned a value of "none", or as "Vis +" if one or more of the sampling points were assigned a value of "low", "medium", or "high".

A potential limitation to this ranking strategy is that it does not account for differences in the amount or frequency of visible vermiculite detections. For example, an area with 1 "low" point

[3] The visual inspection SOP CDM-LIBBY-06 uses the terminology "intermediate" to refer to the "medium" classification. For the purposes of this document, the term "medium" is retained to correspond with the accompanying field documentation.

and 29 "none" points and an area with 24 "medium" points and 5 "high" points would both be ranked as "Vis +".

Option 2: Detection Frequency

In this approach, an area is assigned a value equal to the detection frequency by visible inspection. For example, an area with 1 "low" point and 29 "none" points would receive a value of 1/30 (3.3%), while an area with 24 "medium" points and 5 "high" points would receive a score of 29/30 (97%).

While this approach does account for the frequency of visible vermiculite, it does not consider the amount vermiculite observed. In other words, an ABS area with 5 " low" points and 25 "none" points would have the same detection frequency of 5/30 (17%) as an ABS area with 5 "high" points and 25 "none" points.

Option 3: Amount-Weighted Score

In this approach, both the frequency and the level of vermiculite are considered. This is achieved by assigning a weighting factor to each level, where the weighting factors are intended to represent the relative levels of vermiculite in each category. As presented in SOP CDM-LIBBY-06, the guidelines for assigning levels are as follows:

None =	No flakes of vermiculite detected observed within the inspection point.
Low =	A maximum of a few flakes of vermiculite observed within the inspection point.
Medium/High =	Vermiculite easily observed throughout the inspection point, including the surface. A ranking of High is reserved for samples that are 50% or more vermiculite. Others (<50%) are assigned a ranking of Medium.

Based on these descriptions, the weighting factors that were used to calculate scores are as follows:

Visible Vermiculite Level (L_i)	Weighting factor (W_i)
None	0
Low	1
Medium	3
High	10

The score is then the weighted sum of the observations for the area:

$$Score = \frac{\sum_{i=1}^{x} L_i \cdot W_i}{x}$$

This value can range from zero (all points are "none") to a maximum of 10 (all points are "high"). For example, an area with 1 "low" point and 29 "none" points would receive a value of 1/30 = 0.033, while an area with 24 "medium" points and 5 "high" would receive a score of (24·3 + 5·10) / 30 = 4.13.

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FINAL Remedial Investigation Report

Operable Unit 8
Libby Asbestos National Priorities List

HDR

June 2013

United States
Environmental Protection Agency
"...to protect human health and to safeguard the natural environment..."